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October, 1935

SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

CONTENTS:

Laboratory Procedures
Natural Color Photography
Primary Pupils Study the Moon
Ability to Apply Principles
Triangle and Tetrahedron
How Water Serves Man

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School Science and Mathematics

A Journal for All Science and Mathematics Teachers

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at 450 Ahnaip St., Menasha, Wis.

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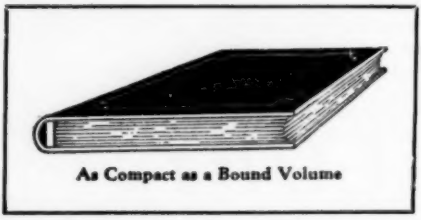

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXV | OCTOBER, 1935 | WHOLE NO. 306

"ALL NON-MATHEMATICIANS BARRED"

For eleven years after the tragic death of Socrates, Plato was in self-inflicted exile from his native city, Athens. He then returned to become head of the great Athenian Academy. He was not a great mathematical genius but he understood the value of mathematics and the dependence of all educational progress on its principles and applications. Because of this he caused the words quoted above to be inscribed over the academy entrance.

Today some of our educators want to make the inscription above our high school doors read, "All Mathematics Barred." This movement is one of the educational epidemics like the now nearly forgotten vertical system of penmanship, that retards progress for a time but is finally eradicated. Mathematics is vital for the progress of all civilization and will soon rise stronger than ever to provide valuable and interesting subject matter for all students. Our secondary school courses in mathematics may have infected spots that should be cleansed and cauterized, but no limbs should be amputated. Let us devote some time to locating the diseased areas and rebuilding the broken down tissue. No doubt we shall find it is ourselves that need improving more than the subject matter. Now is an opportune time to demand better teaching and better preparation for teaching. Preparation means first a thorough mastery of subject matter; a genius cannot teach others a subject he does not know himself. Preparation implies sincerity of purpose; the teacher should have a will to *teach*, not merely to hold a teaching position in order to make a living while he is doing or preparing to do something else. Teaching should be the most respected of all the professions. Only teachers can make it so.

CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, INC.

The Central Association of Science and Mathematics Teachers was organized in 1903 for the purpose of emphasizing the relationship between mathematics and the sciences, to develop courses co-ordinating mathematics with science and the different sciences with each other, and to encourage the improvement of classroom technique. Many modern methods of educational procedure have been and are now being fostered by The Central Association. Outstanding teachers in the high schools and colleges throughout the Central States have been included in the membership since the time of its inception. At present many members are engaged in the development of techniques designed to aid in the solution of modern educational problems. The work of the Association is accomplished through the agency of its members, its committees, the Annual Convention, and through its official journal, SCHOOL SCIENCE AND MATHEMATICS, which enjoys a wide circulation throughout this country and also goes to many foreign countries.

An examination of the files of SCHOOL SCIENCE AND MATHEMATICS will reveal facts as follows: (1) It is owned by teachers, managed by teachers, and edited by teachers. (2) It comes to your desk every school month. (3) It is devoted to the problem of science and mathematics teaching. (4) It aims to solve teaching problems and provides classroom helps and special teaching devices for difficult topics. (5) It publishes articles, not only from leaders in research, but also from outstanding classroom teachers, thus providing variety in subject matter and point of view. (6) It emphasizes co-ordination of subject matter. (7) It carries a most stimulating feature in its problem department and science questions department, both of which are widely used in high school and college classrooms and by student clubs. (8) It promotes the natural articulation of science and mathematics. (9) Publishers value its book review department and teachers find this department useful in evaluating texts. (10) It is rated highly as a reference for courses in education. Many bibliographies contain more references to SCHOOL SCIENCE AND MATHEMATICS than to any other educational journal. (11) In its thirty-four volumes it epitomizes the superior professional achievements made during the past generation in both science and mathematics and also in educational methods.

The 1934–35 Convention

The annual convention of Central Association of Science and Mathematics Teachers will be held in Chicago at the Palmer House Nov. 29 and 30, 1935. The following noted educators will take part in the program: **Dr. George D. Birkhoff,** Harvard, on *The Relationship of Mathematics to Art, Poetry, and Music.* Dr. Birkhoff is the author of the recently published book on *Aesthetic Measure.* **Dr. Arthur Koehler,** U. S. Forest Products Laboratories, Madison, Wisconsin, on *The Importance of the Scientific Study of Wood.* Dr. Koehler was the wood expert at the Hauptmann trial. **Dr. Arno B. Luckhardt,** Rush Medical College Chicago, on *The Value of Animal Experimentation.* **Dr. F. R. Watson,** Acoustics Laboratory University of Illinois on *Selected Topics in Acoustics, with Experiments.* **Dr. E. J. Moulton,** Dean Graduate School, Northwestern University on *The Future of Mathematics in our Educational System.* **Prof. Mamie Logsdon,** University of Chicago, on *The Development of a Course in Junior College Mathematics.* **Dr. Otis W. Caldwell,** Professor Emeritus, Columbia University, will address the Elementary Science section. **Sam Campbell,** noted conservationist, will show his splendid films. Other speakers are **Dr. Georges VanBiesbroeck,** Yerkes Observatory; **Miss Bertha M. Parker,** University of Chicago; **Prof. N. Henry Black,** Harvard Physics Laboratories; **Dr. Harvey Lemon,** University of Chicago Physics Laboratories; **Dr. Wilbur Beauchamp,** School of Education, University of Chicago; **Dr. Glenn Hobbs,** Head of Technical Department, Welch Scientific Company, Chicago; **Dr. H. O. Lathrop,** Head of Geography Department, Illinois State Normal University, Normal, Illinois; **Prof. Walter W. Hart,** Mathematics Department, University of Wisconsin; **Dr. Philip Church,** Specialist in Oceanography, Evanston Illinois High School; **F. W. McCurry,** Chief Chemist Derby Oil Company, Wichita, Kansas; **Paul Edwards,** Supervisor of Science and Visual Education, Chicago Public Schools; **Miss Mary Melrose,** Supervisor of Elementary Science, Cleveland Public Schools; **Prof. Ira C. Davis,** University High School, University of Wisconsin.

The November issue of SCHOOL SCIENCE AND MATHEMATICS will carry the program in full.

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5. The annual convention is always held in some large city favorably located in the middle west, thus permitting regular attendance without great expense.

6. You can help the Association accomplish its work, and thus identify your self with the outstanding movements of your profession.

Fill out the membership blank on page 679. If mailed before October 10 your name will appear in the membership list of the 1935 Yearbook.

MARIE SANGERNEBO WILCOX, *Membership Chairman*
KATHARINE ULRICH, *President*

PLANTS, WEAKENED BY ONE DISEASE FALL EASY PREY TO OTHERS

Plant diseases, no less than diseases of human beings, give new point to the old adage that "troubles never come singly." A plant, weakened by the attack of one fungus, falls prey to some other disease the more easily, just as a man may be prepared for pneumonia by an attack of the "flu."

Cases in support of this thesis were cited by F. T. Brooks of Cambridge University, in his presidential address, delivered before the botanical section of the British Association for the Advancement of Science.

When a log lies rotting on the ground, it is attacked by one fungus after another, as a rule, rather than by several species of fungi simultaneously. The species observe a regular order in their coming and going, resembling the "succession" among higher plants, where an oak forest, for example, succeeds one of pine, and afterwards beech and maple may replace the oak.

Varieties of wheat, bred to be especially resistant to the rust disease, may be attacked by mildew. Afterwards, rust is able to invade them where the mildew has been growing on their stems and leaves. The same "preparation" for rust may be made by another fungus disease known as bunt.

Another combination involves fungi and the invisible viruses of such diseases as leaf mosaic. The fungal cause of the terrible potato-blight disease, that caused famine in Ireland in the 1840's, followed by wholesale waves of emigration to America, was once resisted by Irish potatoes which now cannot hold out against it at all. Mr. Brooks cited the opinion of one of his colleagues that this increase in susceptibility was due to the prevalence of the virus disease, potato mosaic.—*Science Service.*

A STUDY OF THE MOON

By Mrs. Frances Snyder
Fulton School, Minneapolis, Minnesota

When first grade children were asked, "Which would you rather watch, the moon or the stars?," the moon was unanimously chosen. Because a few questions revealed the fact that the children had almost no knowledge of the moon, we asked them to look in the sky for it and report what they saw.

These guides for observation and reports were placed on the board:

1. Did you see the moon in the east, north, west, or south part of the sky?
2. Was it high or low in the sky?
3. What color was it?
4. Draw a picture of it as you saw it.

Cloudy weather and no moon in the sky was the next morning's report, but at recess the third quarter of the moon was discovered and we all went out to the playgrounds again in order to see it. The children readily told me that it was a white moon and that the sky was light blue. To my surprise the group insisted that the moon was round. In order to gain a fuller meaning of *round*, we cut a circle from paper to represent the moon. We folded it in half, then in more than half, then in less than half, and at each folding compared our paper with the moon in the sky. We then drew the moon which we saw in the sky on the board. We noticed that the outline was not a whole circle. Records which came in later fulfilled my hope that this activity would insure more accurate observations.

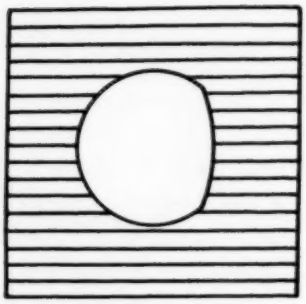
Daily records came in very crudely written at first on any kind of paper from Mother's best stationery to the back of gum wrappers. The enthusiasm of the children was beyond my greatest expectation. They came in very early in the morning eager to show me their records or to write their stories and draw their pictures on the board, or perhaps someone had lost his record or had forgotten it and wished to report orally.

We decided that we must keep a class record large enough for all to see. For this we used a large piece of oak tag. In the morning as the children came in they copied their records on the board in order that they might be available for class discussion. After the children had studied and compared the reports and decided upon the correct form and color of moon and sky, a

child was chosen to cut a yellow or white paper moon and to mount it on light blue or dark blue paper for the record. The children then chose the best sentences from the stories on the board or from oral reports. Sometimes they chose the complete story of one child. The chosen story was then dictated as I wrote it beside the picture.

The following stories and pictures taken from records illustrate the work of the children.

CHILDREN'S STORIES



October 25

We all saw the moon this morning.
It was white.
It was not quite round.
The sky was light blue.
The sun was in the east.
The moon was in the west.
The moon was opposite the sun.

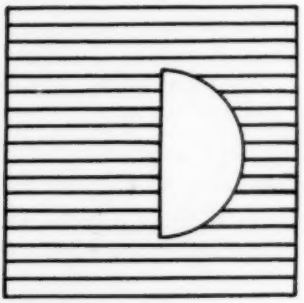
This is Peggy's Story

(November 4)

"Mother and I went out to see the moon.
It was not there.
Daddy came home later.
He said he saw only the stars."
Bartley contributed, "It was the 'dark of the moon.'
Then the moon does not shine at night."

November 12

Almost everyone has seen the moon.
It is the first quarter.
We saw it in the southwest.



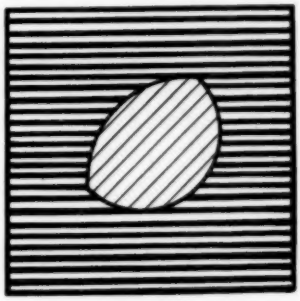
November 14

We saw the moon this afternoon at recess.
It was a white moon.
It was just about half.
It was in the east.
It was high in the sky.

Several cloudy evenings interrupted reports but did not dampen childish ardor.

November 19

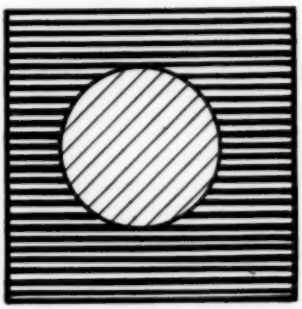
Jack counted 18 children who saw the moon last night.
It was more than a half moon.
It was in the east.
It was high in the sky.



This is John's Story

(November 21)

"I was coming home from a friend's house last night.
I looked up in the sky.
I saw the full moon.
It was in the east.
It was high in the sky.
When I got home I looked out the window.
The clouds were almost over it."



This is Nancy's Story

(November 30)

"I saw the moon.
It was in the southeast.
I saw it at seven o'clock this morning.
It was the last quarter."

Key for Illustrations

Light blue sky

Dark blue sky

White moon

Yellow moon

On December 10, children brought records of the new moon again. Emmy Lou's picture turned the moon one way. Rosemary's turned it the opposite way.

ROSEMARY EMMY LOU

This aroused discussion among the children which ended with the following conclusions:

"We will look for the new moon tonight.
We will make a picture right after we see it.
We will see whether Rosemary's or Emmy's picture is correct."

A Mistake Corrected

Twenty-seven children saw the new moon last night. It was in the southwest. All of the children think the moon is like Emmy's. Rosemary made another picture today. She made the moon like Emmy's too.

A Contribution

John said, "The new moon is like Emmy's and the old moon (or the last quarter) is like Rosemary's." Looking at the last month's record and pointing to the new moon, he continued, "We have our other moon made the wrong way. We will have to make a new one."

Daniel said, and illustrated with a paper moon, "We do not have to make another picture. Just turn it around."

Without much ado the boys fixed the record.

Although no class record was kept after the moon's cycle of change had been completed, the children's interest continued as was evidenced by their reports, discussions, and questions.

For my personal satisfaction I summarized the outcomes of our study of the moon in this way:

The children achieved certain skills in observation and in

drawing conclusions as was evidenced by their reports of form and position of the moon and of color of the sky. They learned the form and the position in the sky of the four phases of the moon. They related the color of the moon and the sky to the amount of sunlight. The element of time telling entered because of their own accord they began reporting the time they had seen the moon. They improved their reports in English as was evidenced by the fact that their first reports of one or two thoughts grew to well written sentences which made a complete story.

Under the leadership of the next teacher, the children are giving oral reports of their observations in Civic League and stories are still brought in. Their interest has continued. I am wondering how long it will continue.

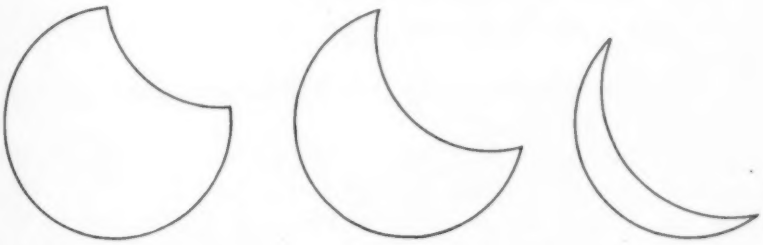
A comparison of the individual and class results of this primary work with the following independent production of a pupil of fifth grade level illustrates children's growth in accuracy of observation and report and in ability to solve more complex problems.—JENNIE HALL, Adviser in Science

THE MOON CASTS ITS SHADOW

BY BARBARA SPENCER, *Fulton School, Minneapolis*

In Minneapolis, February third, there was a partial eclipse of the sun. I wanted to watch it. I looked at the sun through smoked glass.

The eclipse started shortly after nine o'clock. At first the shadow appeared at the upper western part of the sun. Then it got deeper on the top. It took about an hour to get the top covered with the moon's shadow.



SHORTLY AFTER NINE O'CLOCK | ABOUT NINE-THIRTY | SHORTLY BEFORE TEN O'CLOCK

Then the shadow passed out on the upper eastern side. It took about two hours to make the eclipse.

The earth rotates on its axis from west to east. It is this movement that makes the sun and moon appear to move from east

to west. The moon moves around the earth. When the moon travels around the earth and its path gets in between the earth and sun, it casts a shadow on the earth. That is what we call an eclipse.

VOCABULARY IN BEGINNING ALGEBRA

By Nelson A. Jackson

Mount Hermon School, Mount Hermon, Massachusetts

Each new word in the language of Algebra should be mastered as it is met. Its meaning should be definitely understood. The pupil should be able to state this meaning, to tell why the word is necessary, and how it is used. A pupil's ability to do clear thinking in mathematics will be largely influenced by his ability to grasp and intelligently use the terms and the rules of the subject. According to Breslich, there must be established, "the habit of connecting words and symbols with meanings." He further states, "Without this habit, pupils employ certain words and principles that are used day after day without ever attempting to comprehend what is meant. . . . If they are ever to outgrow this mechanical way of studying mathematics, they must form the habit of being sure of the meaning of the terms which they use in mathematical discussion."*

In this study the meaning of the word vocabulary has been broadened to include not only terms but rules and principles.

With what degree of success does the average first-year Algebra pupil master the required vocabulary?

How well is the vocabulary of arithmetic carried over into Algebra?

Is too much expected of the pupil insofar as acquiring a new vocabulary is concerned?

In order to throw some light on the above questions, three standard texts have been carefully examined for terms and rules, and a study of the ability of first-year Algebra pupils to acquire a working vocabulary has been carried on with a group of 97 boys for 15 weeks.

Each of the three texts examined is representative of a type. The first is one of the modern texts which present Algebra according to progressive methods without undue emphasis on

* Breslich, Ernest R. *Teaching of Mathematics in Secondary Schools*, University of Chicago Press, 1930, p. 96.

some fad. This text in the first 75 lessons covers topics of formulas, equations, problems, graphs, signed numbers, and the four fundamental operations with monomials and polynomials. In the presentation of these topics 97 terms, rules, and principles are used, 25 of which should have been mastered in arithmetic.

The second text, which is the one used by the classes in this study, bridges the gap between the ultra and the old-line texts of 25 years ago. In it the material is presented largely from the standpoint of the College Board requirements. In giving this work, the text uses 111 terms and rules, 35 of which come from arithmetic.

The third text is one in which the material of a book of the last generation has been revised and modernized to meet recent demands. In this work 108 terms and principles are used, 30 of which are from arithmetic.

The number of topics presented in the first text is the least, and that in the second is the most. The number of new terms, rules, laws, and principles in the three texts which must be mastered by the pupil in 75 lessons is respectively 72, 76, and 78. This means that in order to progress, the student must necessarily assimilate at least one new idea each day and review one of the terms from arithmetic every other day.

The acquisition of the necessary vocabulary is only one of the many things in Algebra which he must accomplish in order to do satisfactory work.

To see how well the average pupil masters his vocabulary, the writer has given a series of tests on the meaning of words used in the everyday classroom procedure in Beginning Algebra, with the cooperation of two of his colleagues. Most of these tests have taken about 10 minutes. They have been given, some without warning, and some have been announced the day before. Only one test has been devoted entirely to vocabulary. That was announced and took 20 minutes. Vocabulary questions, when given, usually made from 10% to 20% of the test. At times the vocabulary question has been given at the beginning of the test; at other times, near the end; and on two occasions it has been used as an extra-credit question.

In the teaching, the importance of vocabulary mastery has been kept before the boys. Most meanings, with the exception of a few from arithmetic, were carefully derived and discussed in class prior to including them in a test.

The accompanying table gives the results obtained with 22 representative words. The figures used in the table are referred to as achievement quotients (A.Q.). They give the percent of boys in the entire group who gave a correct meaning of the word in fairly good English.

A TABLE OF ACHIEVEMENT QUOTIENTS IN VOCABULARY IN BEGINNING ALGEBRA*

Day of Recitation	7th	9th	11th	14th	16th	19th	24th	40th	43rd	73rd	Final Exam.
Vocabulary											
Addition								82			
Angle								65			
Binomial	47	72						84		66	
Complementary Angles								72	53		
Equation			53	47	65	71	58	70		40	
Exponent								74	63	58	82
Formula	57	83	84	63	70	95		66		69	81
Monomial								84			
Parallelogram								52	60		
Perimeter					87			92			
Product								71			
Polynomial				44		64	60	70		56	
Problem								46			
Rectangle				51	91		62	76		58	71
Substitution						69	54	94		72	
Supplementary Angles								80			
Triangle	80	92						94			
Terms—like					64	44				50	
Terms—unlike								68	57		
Terms—algebraic	24	48					49	60	47	63	65
Fraction										66	
Trinomial			68					94			89

* Read table. The meaning of binomial was asked for on the 7th, 9th, 40th, and 73rd days of recitations, the respective A Q.'s for which were 47, 72, 84, and 66.

The test on the 73rd day was given without warning on the first day of recitations after a two weeks' holiday vacation. The A.Q.'s of that test certainly represent the mastery of knowledge which has been thoroughly assimilated. The results are far from satisfactory.

A study of the table shows that there was no regularity of response and no constant trend towards improvement.

The test on the 40th day was entirely a vocabulary test and was announced the day before. The boys in preparation appar-

ently made a special review of their vocabulary. In only two cases did the A.Q. fall below 60. In neither of these cases had the work been especially emphasized or discussed. On the 42nd day the corrected papers were returned and discussed by the class. No mention of vocabulary was made on the 42nd day. The test on the 43rd day was given without warning. A glance at the table shows that in only one case was there an improvement in the A.Q., and this was for a word which comes from arithmetic. The special review seems to have been for the day only.

The mean A.Q. for the 7 words, addition, parallelogram, perimeter, product, rectangle, triangle, and fraction, which come from arithmetic, is 73.9. Only 3 of the 15 A.Q.'s for the above words were below 60, and these were for parallelogram and rectangle. The concepts of the meanings of words which come from arithmetic seem to be fairly well in mind.

In looking over the various tests, the examiner has noted very many crude expressions, which indicate that the pupil had not the faintest idea of the meaning of the word which he was trying to give, e.g. "Exponent is the remainder used in division." "Angle is a figure in which one has to find the relationship." Other statements show that the pupil had an idea of the desired meaning, but that it was not organized, e.g. "A parallelogram is a four-sided figure with all sides parallel." "A formula is a standing of laws by means of symbols." "An equation is a sign of quality between two quantities." Again errors came in a perfectly understandable manner on account of the confusion of terms, e.g. "Unlike terms are terms with unlike signs." "A parallelogram is a rectangle that leans." At another time the meaning given by the boy, while not strictly mathematical, was most emphatically common sense, e.g. "Problem equals a situation usually taken from life to be solved." "A problem is a complicated situation." "An exponent decides how many times a number is multiplied by itself." "Unlike terms are terms that are different."

No general conclusions can be drawn from this study. It has covered too short a time, and the number of A.Q.'s figured is too small. The results are not satisfactory. However, certain tendencies are indicated, at least so far as the group studied is concerned.

Textbook makers and teachers are trying to cover too much ground during the first part of the course in Beginning Algebra.

In the usual course the pupil does not have time to assimilate

the new language and in many cases fails to realize the necessity for doing it. Oftentimes the teacher is at fault in not emphasizing the importance of vocabulary mastery.

In most instances the meanings of words which have come from arithmetic seem to be fairly well understood and the words are used intelligently.

In one of the most widely used Algebra texts of 25 years ago, 16 of the first 20 pages are entirely given over to the statement of definitions, laws, and principles. Has the present-day teacher in his reaction to such a presentation gone too far in the opposite direction?

HOW DO YOU USE YOUR DICTIONARY?

For many people a dictionary is merely a book that spells and defines words. But a good dictionary does far more Here is an example from just one of the appendices *Webster's New International Dictionary, Second Edition.*

In the Gazetteer there are 35,000 entries, a number likely to satisfy all but the most unusual and rare needs. Here one can find that *Istanbul* (pronounced ē′stän.bo͞ol′), formerly Constantinople, is a vilayet (province) of Turkey, partly in Europe (1,293 square miles, with a population of 623,000) and partly in Asia (823 square miles, with a population of 171,000), lying on both sides of the Bosporus; and that it is also a city, the capital of the vilayet. By turning to *Constantinople*, to which a cross reference is made, one finds that it was until recently the name of Istanbul and was formerly the capital of Turkey. Further cross reference is made to *Byzantium* and *Stambul* in the Gazetteer, and to *Byzantine* and *Saint Sophia* in the vocabulary. One can also find that Northampton is the county seat of Hampshire County, Massachusetts, with a population of 24,000, and that Smith College is located in it. It is such information that the average reader ordinarily wants.

PROPER CHOICE OF GRAZING ANIMALS HELPS IN RIDDING LAND OF WEEDS

Weeds in a farmer's pasture may be an indication that he does not have the right kind of animals in it. Frequently one kind of farm animal will eat plants rejected by others. Observations of animal feeding habits and the selection of stock that will clean up a particular weed species will aid toward the solution of a weed problem.

This suggestion in common sense applied botany was offered at the Sixth International Botanical Congress by Dr. Winifred E. Brenchley of the Rothamsted Experimental Station, Harpenden, England.

Dr. Brenchley has observed, in English pastures, that cattle will eat bracken-fern but will not touch broom-weed, while sheep like broom but will not eat bracken. To blanket the pasture-weed problem, Dr. Brenchley recommended running horses, cattle and sheep in the same enclosure. Weeds that can stand up against their combined preferences must be voted hopeless.

MEASURING ABILITY TO APPLY PRINCIPLES

By A. W. Stewart
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Progressive thought is critical of knowledge as an outcome of education unless that knowledge is functional. In the ideal school it is assumed that there is an intimate relationship between knowing and doing. Applied to science this means that the important aim in science is the appreciative understanding of a body of principles and laws, and the ability to use these principles and laws in the solution of problems and the interpretation of the various aspects of one's environment.

Another principle of teaching, admittedly important, but often neglected in practice is that tests and testing programs have a reciprocal effect upon the learning which they are set up to measure. A modern and progressive statement of objectives in the course of study accomplishes very little if the resulting achievement is measured by tests that bear no relation to the objectives.

If these statements are correct, it follows that one of the most important problems in connection with the building of science tests is that of devising and improving types of tests that will give a valid measure of the pupil's ability to understand and apply the important scientific principles included in his instructional course. The terms understand and apply are both used here because it is believed that understanding is attained largely through application and use; that, conversely, intelligent application always depends upon understanding. Each supplements the other. Tests, therefore, that measure understanding are also true measures of ability to apply. Likewise, a test of ability to apply a principle is certainly a test of understanding. Obviously it is not always easy to differentiate between the two types.

The purpose of this paper is to present and discuss several types that the writer has used in the Ohio State Scholarship tests in physics and general science. Some of these have, no doubt, been used by others. They are presented here as types useful in measuring the ability to understand and apply principles.

The simplest test for this purpose consists of a list of the principles studied and a list of questions, situations, and devices. In each question the pupil is asked to select the principle or

principles applied. The scoring is somewhat complicated if more than one principle is applied. The sample below illustrates the type:

(4) 1. Which principle is most important in the dynamo?	1. $I = E/R$
(1) 2. Which one is involved in a "short circuit"?	2. Like charges of electricity repel each other.
(3) 3. Which one accounts for the working of the electric door bell?	3. An electric current is surrounded by a magnetic field.
	4. Principle of induced currents.

In this type the law is usually stated rather than named. In some cases, however, the statement of the law makes the answer too obvious and, in such cases, the name of the law may be given. This requires recall of the law and is, therefore, more difficult.

A second type, I have called "true-false with reason." It consists of a column of true and false statements and, at the right of this, another column of laws and principles. The pupil must mark each statement + or 0 and follow this mark with the number of the law upon which he bases his first mark. Thus, the +4 before the first question below shows that the statement is true and that it is consistent with law number 4. The 01 before question 2 shows that the statement is false and that it is inconsistent with principle number 1:

If the statement is true, mark it plus, if it is not true, mark it zero. Next follow this plus or zero with the number of principle in the right hand column which was the basis for your first mark.

Statements	*Principles*
+4 1. A rock will sink to the bottom of the ocean.	1. Newton's first law of motion.
01 2. A simple pendulum on a ship swings east and west. If the ship changes direction the direction of swing will also change with the change of the ship.	2. Air pressure at sea level is less than 15 pounds per square inch.
02 3. Mercury can be lifted by a lift or suction pump a distance of 4 feet.	3. Pressure in a liquid is proportional to depth.
	4. An object in a liquid loses weight equal to the weight of the liquid displaced.

No credit is given unless both marks are correct. Chance is greatly reduced in this type. With five laws the chance of guessing both answers is only one in ten. With seven laws it would be one in fourteen, etc. In the 1934 Ohio State Physics Test, Part III consisted of 26 such questions. The reliability coefficient for this part was $.81 \pm .02$ although it constituted only one-fifth

of the whole test. The whole test required an hour and had a reliability coefficient of $.93 \pm .01$. No measure of validity is available except the correlation with the whole test. This coefficient was $.69 \pm .03$ and may be taken to mean that this portion of the test measured an ability differing somewhat from the rest of the test.

A third type is an adaptation of the multiple choice test. It is best understood from a sample:

2 The principle in accordance with which the balloon is supported in the air is the same as that applied in the (1) airplane (2) submarine (3) flying bird (4) kite.

The merit of this type lies in the fact that neither the name nor the statement of the law is given. It may be that the most functional concept one can have of a given law consists not of words nor name but rather acquaintance with its applications. In other words one might be unable to repeat Newton's first law of motion or even associate the meaning with the name of the law and still be functionally aware of the phenomena of inertia. If this is true this type of test should be a valid measure of a worthwhile outcome. In the 1933 Ohio General Science Test, consisting of 116 items, Part IV consisted of 14 of these multiple choice items. The reliability of Part IV was $.64 \pm .04$ although it constituted only about one-eighth of the hour test. The reliability of the whole test was $.94 \pm .01$. The application of the Brown-Spearman Prophecy Formula gives a predicted reliability of .93 if the whole test had been of this type. Among the five parts of the test the validity of this part ranked second when correlated with the total test score.

Another adaptation of multiple choice is that in which only two applications are given, where one or both may be true. An example follows:

1 The principle of buoyancy is applied in (1) the balloon (2) the airplane (3) both (4) neither.
3 Pascal's principle is applied in (1) hydraulic brakes (2) the barber chair (3) both (4) neither.
4 The electric door bell involves (1) the principle of induced currents (2) electrostatic induction (3) both (4) neither.

A merit of this type is that only two multiples are necessary. The difficulty in making a multiple choice test is the selection of wrong responses. Furthermore, the validity of the test depends upon a careful selection of these "wrongs." They must not be too nearly right and, on the other hand, they must not be too

obviously wrong. The smaller the number of choices the more carefully they may be chosen. However, reducing the number of choices increases the element of chance. The "both-neither" type allows two choices and yet holds the guessing chance to one in four. The second merit is that it requires thought, rather than memory. A pupil depending on memory might recall that the barber chair was mentioned in class as an application of Pascal's principle but fail to recall that hydraulic brakes were also mentioned. On the other hand, a pupil who really understands the principle and also the devices, will not make this error. To the latter the two devices are related through the principle involved. It seems, therefore, that this type of test would differentiate between the pupil who thinks and the one who remembers.

A third modification of the multiple choice is that in which four multiples are given, two to be chosen. Since two choices can be made from four multiples in six different ways the chance of guessing is reduced to one in six. If one cared to use five multiples the chance would be one in ten. In addition to the reduction of the guessing factor this type has the merit of differentiating between thought and memory as in the preceding type. An example of this type follows:

23 Applications of the principle of induced currents are (1) a buzzer (2) magneto (3) dynamo (4) electric crane.

To bring to your attention the thought involved in this type, consider its use in informational material:

23 Leaders in the American Revolution: (1) General Robert E. Lee (2) General Washington (3) Nathaniel Greene (4) Stonewall Jackson.

Quite obviously a pupil might remember that General Washington participated in the war and forget General Greene. In such a case he should have credit for half an answer. On the other hand, a pupil who knows that a dynamo is an application of current induction but does not recognize the same principle in the magneto, has a doubtful understanding of the principle of induction. One suspects that, at best, he only remembered and, perhaps, only guessed. It appears, therefore, that this type is, satisfactory for testing thought but not for testing information.

Summarizing: The improvement of tests to measure understanding and the ability to apply one's knowledge is a field that should be inviting to test makers including teachers. Types sug-

gested here are: (1) Simple identification of the principle or principles applied in a given application, (2) true-false statements with principles involved (3) multiple choice, in which a device is recognized as applying the same principle as another one named in the question (4) multiple choice in which the correct answer is one or the other, both or neither of two choices, (5) multiple choice where two of the multiples are correct and no credit given for one.

CALIFORNIA'S "ORPHAN PLANTS" ONCE GREW ON CHAIN OF ISLANDS

California has a whole chain of "plant orphanages," where species of plants are found in limited areas and nowhere else in the world. These were described before the meeting of the Sixth International Botanical Congress by Professor W. L. Jepson of the University of California.

All the endemic, or orphan plant, areas he pointed out were once islands but some of them are now mountains rising up to 6,000 feet in altitude. The original flora of the geologically-ancient islands has been taken for a gradual slow ride upward without apparently being changed thereby.

Of more than 5,000 species of higher plants in the state of California some 2,000 of them are of endemic, or "orphan," types. To show how widely varied is the flora of California it may be recalled that in the whole northeastern quarter of the United States there are only 3,500 species of higher plants altogether.

Since the days when Darwin and Wallace popularized the idea of evolution, the role of island isolation in enabling new species to develop has been taken as an axiom among students of the life sciences. Here, then, Professor Jepson pointed out, was an ideal situation for the development of large numbers of unique and solitary species of plants.

Many of the areas would not now impress the casual observer as former islands. Some of them are rather lofty mountains. Professor Jepson pointed out certain instances in which these endemic-bearing areas have been elevated from 1,000 to 6,000 feet, carrying their plants with them. And the plants, curiously enough, seem to have been changed relatively little by their slow ride high into the air.—*Science Service.*

TO SHOW THE CIRCULATION OF THE BLOOD*

By EDWIN F. JACOBS, *Ashland College, Ashland, Ohio*

The time-honored method of showing the circulation of the blood has been by using the web of a frog's foot. I have recently found that it can be shown to an advantage in the lungs of a frog by the following method:

The frog should be partially chloroformed, then laid open with a knife, exposing its heart and lungs. The lungs should then be inflated by the use of a blowpipe and the frog placed on the stage of a microscope with the lungs in focus. Not only can the circulation of the blood be seen, especially if the magnification is not too high, but also the action of the breathing. Wide field binoculars are best for the experiment.

* This experiment is illegal if done in the high schools in Illinois, possibly also in some other states.—Ed.

A NEW LOOK AT THE SCIENCE LABORATORY

By Joseph A. McGee
Seymour High School, Seymour, Connecticut

The relative value of demonstration versus individual laboratory as a method of teaching the natural sciences has been under investigation for some time. There are experiments in this field in process at the present time.

Some teachers of science are disturbed by the usual procedure used in these investigations of evaluating the laboratory work by subject matter tests alone. Vital elements in science appreciation are left out in this type of testing. There are values present in laboratory work which are not disclosed by subject matter testing.

The revolt against the assumption that ability to answer questions is the chief aim and the only measure of education is evidenced by the great extreme that some have advocated in the other direction. They would not even measure subject matter. This extreme, like extremes in any phase of living, is reactionary and needs correcting. Yet it has its values. The value is the calling of attention to the error of its antithesis.

During the last few years some evidence relative to values of laboratory work arose as a subsidiary problem under the main problem of how the sciences of physics and chemistry could be made more interesting to the pupils of Seymour High School. Data for this main problem have been collected for three years. And each year the enthusiasm shown by pupils for laboratory work has been outstanding. The value of this evidence does not rest on the validity of any scientific procedure, for gathering such data was not part of the problem. The data are simply an accumulation of statements voluntarily offered by some two hundred pupils over a period of three years. Less than two percent of the total number of responses were unfavorable to laboratory work.

In education there is a growing demand for a new evaluation of educational material in the light of pupil preferences. The fact that pupils demand a chance to do their own experiments reopens the question of laboratory method versus demonstration method and presents evidence that previously was not considered. It is still a vital question only partially solved.

Some evidence of pupil interest in laboratory will be found in the following typical quotations from pupils' papers written on

the subject of "How could chemistry have been made more interesting to me?" The papers have been submitted at the end of the school year for the past three years. Submitting the paper was optional on the part of the pupil.

William A. writes in part "The most interesting part of chemistry is in the laboratory doing experiments brought in from other sources than the books given to us. These were interesting because we did them of our own curiosity. All experiments should be done by students except in a few instances."

Bob M. writes in part "I think we should do more laboratory experiments."

Katherine A. writes "I think chemistry could be made more interesting by having more laboratory work. It seems to me we do not experiment enough. We all, I am sure, would find it more worthwhile to study it if we did."

Nicholas H. writes "The reason I enjoy chemistry is because of the laboratory work. The reason I like laboratory is that I get much more out of chemistry experiments when I do them myself than when I see them done."

Erna S. writes "I have felt only one disappointment in the course. I had hoped and expected to obtain more from chemistry laboratory by experiment. When I entered the course I had the idea that by far the greater part of the course would consist of laboratory work."

One pupil suggested that the entire year be spent in the laboratory.

It seems necessary to state that this class spent a larger proportion of their time in the laboratory than is the case in many high schools. Most of the demonstrations, except at the beginning of the year, were done by pupils who had prepared and practiced them previous to the class period. Class work is necessary to discuss theories not obvious in laboratory work, for reviews, and check-up quizzes, for introductory work and so on. Many features of the science work which these pupils singled out as valuable require class time. It would not be wise, it seems to us, to devote too much time to laboratory nor does it seem wise to devote too little time to this activity. It may be that pupils in the eleventh and twelfth grades profit more by laboratory work than in the lower grades.

As the main question was "How could chemistry have been made more interesting to me?" There were naturally other interests mentioned which were enjoyed by the chemistry pupils

and a demand expressed for more of them. These other interests were trips to industrial plants, chemistry information usable in their own daily life, short talks on personal improvements, and other specific interests.

Considering the growing recognition of educational values where pupil interests are in evidence it seems justifiable to question the finality of any conclusion respecting the value of laboratory work based solely on tests of subject matter.

A new approach to the value of laboratory work is needed. The previous approach was, "How much subject matter is learned from laboratory?" The new approach should be "What are the educational values of laboratory?" Although this latter question has been asked to a small extent the former has been the usual approach.

To summarize, some two hundred pupils over a period of three years mentioned laboratory work as one of the most interesting and valuable features of their eleventh and twelfth year science. Many experimental data have been gathered on the efficacy of laboratory in teaching subject-matter as measured by the usual test with the results rather inconclusive. This evidence seems to call for a new approach to laboratory work; one that asks, "What are the educational values of the laboratory?" There have been but few data gathered from this approach.

TREES GROW ON HIGH MOUNTAINS IN MIDDLE OF SAHARA DESERT

Mountains in mid-Sahara are not the sun-baked piles of barren rock which popular imagination, fed by Hollywood versions of the Foreign Legion, has pictured them. They manage somehow to gather enough moisture to support vegetation, even a growth of trees.

At the meeting of the Sixth International Botanical Congress, Professor René Maire of the University of Algiers told of his explorations in what is probably the least-known botanical region of the world, the high mountains of central and southern Sahara, which rise to heights of 6,500 to 10,000 feet.

Earlier travelers' tales had clothed them with "forests" of pistachio and cypress pine, trees unknown in the New World. Under the more critical botanical eye of Professor Maire, these forests dwindled to a thinner growth, mostly of pistachio and a kind of desert cypress. He did not deny, however, that denser forest growth may once have existed there, in a bygone age when the Sahara itself was a grassland instead of a desert.

Among the trees, and above them on the treeless mountain-tops, were lower growths of shrubs. Prominent among them the exploring botanist found a bush botanically related to the sagebrush of western North America. In general, Professor Maire stated, the vegetation of these mountains has been derived from that of the shores of the Mediterranean. —*Science Service.*

HOW WATER SERVES MAN

A Unit in Ninth Grade General Science

By L. H. Fuller and T. J. Kuemmerlein
Boys' Technical High School, Milwaukee, Wisconsin

This unit is the result of the feeling on the part of the authors that many of our texts in general science do not include enough applications to local situations. If this type of procedure were to be carried on with all the units in a year's work in science, we would not intend it to supplant any text, but rather to supplement a good text. We, in Milwaukee, have a situation that is typical of many cities on the Great Lakes. That is, our drinking water comes from the same body of water that receives our sewage.

Rather than have the child study situations that are more or less difficult, we feel it more important that he know his own city first. It is a great deal easier and far more interesting to discuss problems on water supply when a child can draw from his own experiences rather than from those of someone else.

It should be possible to adapt this type of unit to practically any city or town. We have found that we can better handle a large class through the use of this method of teaching than through some others. We have made provision, too, for a wide range of individual differences due to the fact that it is very flexible. The poorer student will get his essential ideas while the brighter ones will be urged on to deeper study and more field work.

If any of the readers have comments or suggestions we would be very grateful to receive them. The text used during this unit was "Problems in General Science" by Hunter and Whitman.

WATER

Do You Know the Answers:

1. What do we mean by pure water?
2. Where does your water supply come from?
3. How can water be made safe for drinking in the home?
4. What is hard or soft water?
5. Are the streams in your community being polluted? If so, what are the principal sources of pollution?
6. What are the dangers to a community of improper methods of sewage disposal?
7. Why are lifeboats sometimes equipped with distilling apparatus?
8. Why does turning on a hot water tap in the kitchen on a cold morning, cause a mist to form on the window?

9. Why is the rain which comes originally from the ocean not salty?
10. Is a bucket of hot water heavier than bucket of cold water?
11. Was it safer for the early settlers to drink from running streams than it is for us to do so now? Why?
12. Would you rather wash clothes in Milwaukee water than in Wauwatosa water? Why?
13. Why are large water tanks built on top of tall buildings?
14. There are two springs about equal distances above and below a hillside farmhouse. From which spring would you advise drawing the home water supply? Why?

HOW WATER SERVES MAN

He was the only one left and he was weakening fast. He clung to the rope and the water beat him back and forth, back and forth, against the brick walls of the tiny chamber. Fifteen had fled from the sudden storm into the top of the cribhouse which capped the water intake shaft they were building. Fifteen men in a seven foot cell soon made the air unbearably foul so they opened the doors to take their chance with the waves rather than die like rats for want of air. Twelve were lost as the giant waves pounded them against the walls and out into the sweeping water. Three clung to a rope hanging down from the center of the shaft. One and then another fell off as exhaustion sapped their strength. When the life guards finally fought their way to the crib they were able to salvage but one life out of fifteen.

Those fifteen men were part of the crew constructing the North Point Intake for the Milwaukee Water Works when the storm of April 20, 1893 broke out. You can see the final crib in place today. Look east of Bradford beach and see the gulls leisurely sunning themselves upon its top. Yet to the men who built that cap and the water tunnel connecting it to the pumping station, it was an awesome, fearful, and hateful thing. They called it "Old Gloomy Hole."

George H. Benzenberg, Milwaukee's Chief Engineer, had been forced to continue the job after the private contractors had given up, following two years of heartbreaking difficulties. Twenty lives were lost, two from the bends, fourteen from the storm, and three who drifted out into the night and whose bodies were never recovered. Even on the last day one man leaned on an untied rope hanging over a beam to "take one last look into 'Old Gloomy Hole'," and fell 150 feet to make the twentieth life sacrificed to give Milwaukee enough safe drinking water.

Not that Milwaukee had always so keenly demanded good

water. On the contrary, one hundred thousand people even as late as 1874 were "dependent upon springs and wells to procure water for household and industrial purposes, and for fires upon the three rivers, scattered ponds and cisterns." Demands for a water works finally caused the Common Council in 1857 to interest the Milwaukee Hydraulic Company in supplying Milwaukee with water. The project was never entered into, and proposals from other private companies during the next ten years failed to be considered favorably by enough aldermen to be accepted. Many reasons, financial, legal, and otherwise, prevented the city at this time from constructing and operating its own system, but in 1868 an engineer was chosen to "make a survey with plans and specifications for the construction of a water works system." He was the man who had designed the system for Chicago, Mr. E. S. Chesbrough. One by one the barriers were removed, so that by 1871 the first Board of Water Commissioners was created to "construct a water works system and to carry on and manage the same." Most of the seven members of that board are known today either personally or by the buildings, parks, statues, or streets named in their honor. They were Alexander Mitchell, John Plankington, Fred Pabst, Edward O'Neil, E. H. Brodhead, and George Burnham.

That first system, large then, looks small today. A three foot pipe stuck out into the lake a third of a mile. Through it two pumps took about two and a half million gallons of water a day. Their total daily capacity was only sixteen million gallons per day. The standpipe in the Water Tower at the east end of North Avenue and the reservoir directly west and across the river in what is now called Reservoir Park supplied the pressure. They hold but twenty-one million gallons.

Our population fast outgrew this system so that in 1890 construction on the North Point Intake was started. That this project was not easy we attempted to show in the opening paragraphs. Here a tunnel, over twice the size of the former tunnel, was extended into the lake almost two-thirds of a mile to an exposed crib (mentioned above). Another five thousand feet out, two parallel trenches were dug in the bottom of the lake. In these lay two pipes five feet in diameter. Their ends were upturned into two cribs submerged in sixty feet of water. So that in twenty years the need for water appears to have grown from a tiny flow of two million to ninety-five million gallons per day.

As the North Point construction was completed Mr. Benzenberg said it would be sufficient for Milwaukee's needs until 1935. He was another expert who guessed wrong; for by 1918 the Linwood Intake, with a capacity four times as large, was put into service and "Old Gloomy Hole" taken out of service until the future would require both. It is probable that his guess at that future date would again be wrong. Even fifty years of active service to the city cannot prepare one to realize the tremendous changes the future brings.

THE CITY OF NEW YORK is on the ocean with plenty of water, but none fit to drink. The Hudson River flows past the docks, polluted beyond any practical method of purification. What to do for its six million people was her problem.

She has bought and connected seven different drainage areas. or some fourteen hundred square miles of rain collecting surface, or watersheds. The Schoharie Area is one hundred and twenty-five miles from the city. Dams were built. The Ashokan, for example, is eighty miles away and forms a lake reservoir of more than a billion gallons out of the Schoharie Creek. All of the reservoirs together can store some two hundred and fifty-eight billion gallons. Using nine hundred million gallons a day, as she does, this would last almost a year. As the population grows, the city will have to have more drainage areas, and hope for rain.

The water is brought to the city through an underground tunnel passing, on its way under the Hudson River eleven hundred feet below sea level. It flows from one reservoir to another as each watershed contributes its share.

Clean at the source, and with the drainage areas patrolled and guarded against any form of pollution, it requires little treatment. However, to rid it of odors and kill some organisms it is sprayed into the air (aerated) just below the Ashokan and Kenisco dams; sterilized with chlorine; and, at times of heavy rainfall, treated with aluminum sulphate and soda ash, to settle any sediment carried. Remarkably free from minerals, it is famous for its softness.

ST. LOUIS is located on the Mississippi twenty miles below the mouth of the Missouri. Her water system has to remove large amounts of mud and sand contributed by the "Muddy Missouri," and treat the sewage of the Mississippi dumped in by the cities "up north." In 1899, before the science of water purification had developed to present standards, the Chicago

Drainage Canal commenced to dump her sewage into the Chicago River, which, in turn, dumped it into the Mississippi. The St. Louis typhoid death rate rose in the following three years to almost double the rate just previous to that time. With a new clarification process added in 1903 the rate dropped remarkably.

The one and a quarter million people are dependent upon several intakes. One is on the Mississippi River five miles below the junction with the Missouri, and another is on the Missouri River thirty-seven miles above the junction. The two plants treat the water alike, pumping it into a settling basin which is sixteen feet higher than a series of basins through which the water flows to remove its impurities. The heavy grit is dropped in the settling basin through which the water very slowly flows. In the lower basins, lime and iron sulphate chemically settle out the iron, aluminum sulphate coagulates to settle out finer particles, and the water then flows through fine sand to catch any coagulated material that failed to settle. A final treatment of chlorine renders the water safe from disease bacteria. It is then pumped to a one hundred million gallon storage tank three hundred feet above and nine miles from the city.

SAN FRANCISCO is almost an island. The Pacific lies west; east the San Francisco Bay; and north the Golden Gate, two miles wide. This leaves land only on the south-east. In the early history the few springs were quite sufficient, but in 1849 Senor Juan Miguel Aguirre received thirty dollars a day for thirty buckets of water. In a fire on May 4, 1851, one man "had no water, but threw eighty thousand gallons of vinegar on the flames and saved his business." So the extreme hardship of water scarcity was made apparent before most of the present six hundred thousand San Franciscans were born.

Many private water companies succeeded one another in supplying the citizens, but out of sixty years of discontent for one cause or another, agitation grew to have the city own and operate its own water works. Due to what they thought an exorbitant price and unreasonable terms the city would not buy the property of the water company near at hand, and instead acquired from the United States Government certain rights to use the Hetch Hetchy River in Yosemite National Park for its source of supply.

Hetch Hetchy gorge, one hundred and seventy miles east of the city, narrows at one point to a width of but twenty feet

at its base. By a dam here and at two other points, six hundred square miles of catchment area is available. The dams were built to store a year's supply, and when more storage is necessary, their levels are to be raised. Every day four hundred million gallons of water falls almost a mile, travels under and over mountains, and finally through a tunnel under the San Francisco Bay. The last is considered one of the outstanding engineering projects of all time. Some of the falling water is used to generate hydro-electric power.

The water, of glacier and snow origin, is almost chemically pure. It is soft enough to save, according to one engineer, over half a million dollars in the city's soap bill.

WAUWATOSA went, for water for her twenty thousand people, neither north, south, east, nor west, but down. Six wells of about seventeen hundred feet depth, with deep well pumps are capable of supplying Wauwatosa with more than one hundred and six million gallons of water per day. Booster pumps take the water from the storage tanks where it was put by the deep well pumps and send it into the mains and the three elevated tanks. These last equalize the pressure throughout the city.

As the water comes from deep underground sources (geologists say that Lake Superior supplies the major portion), it is entirely free of waste products but contains a large amount of mineral matter in solution. No steps are taken to purify the water other than an annual flushing of mains, and chlorination of newly laid pipes. This is to guard against danger from wastes that might collect in the process of laying. All pumps are electric and automatic, so that but eight men, including the meter readers and office help, are needed to operate the system.

MILWAUKEE has Lake Michigan at her door step, which under present conditions provides an inexhaustible supply of potable water. However, she must use this same lake to receive her dangerous wastes, unless she wishes to imitate Chicago and build a canal west to some tributary of the Mississippi river. At present we are using the Linwood intake, out a mile and a quarter and some five miles north of the harbor entrance where our three rivers dump what they carry into the lake. Don't look for the crib, because it is sixty-seven feet below the surface, and the tunnel to the shore is ninety-three feet below that. Underground tunnels carry this water from the shore end of the intake to the pumping stations at North Point and Riverside. It would be possible to take more than 300,000,000 gallons from this

intake, and the old North Point Intake is still good for a 95,000,000 gallon delivery should the need arise. The combined pump capacity of the two stations is about equal to the capacity of the Linwood intake, and most of the pumps are low pressure pumps for ordinary work. Some, however, can raise the water 275 feet if necessary.

Reservoirs are used by the Water Works Department to equalize the pressure on the mains and faucets. In speaking of the reservoir in Reservoir Park, Superintendent Bohmann says, "only a fraction of the water passes through the reservoir." The pumps operate at a fixed and efficient speed. "If, during the day hours, the consumption is somewhat greater than the rate of pumpage, the water in the Reservoir is slightly lowered. As the consumption decreases, the loss in the Reservoir is again made up." You have probably seen the high pressure reservoirs either in Jackson Park or where Hawley Road crosses West McKinley Avenue. They are in use only during the summer when lawn sprinkling makes a heavy demand on the pumps.

Wastes from various industries, from other cities, during severe storms, and from Milwaukee itself, make it necessary that we treat the water of the lake before allowing it to be used for drinking. We also dilute the Milwaukee River by pumping lake water into the river just below the North Avenue Dam, and speed the flow of the Kinnickinnic near the South Shore Park. This requires the use of "flushing tunnels," and in action is somewhat similar to the flushing of a toilet. Most of us are familiar with the fact that we sterilize the water with chlorine. The extreme care used in this method is described under Problem IV, Section C. Since the development of the Milwaukee Metropolitan District Sewage Disposal Plant, considerable less treatment is necessary than in former years, but even today some communities and industries are able to pollute Milwaukee's drinking water, and care must be constant to eliminate much of the material that still flows into the lake that must be Milwaukee's sole water supply.

PROBLEM I.

1. Which city had to buy and protect large drainage areas of unpopulated land?
2. Which city after sixty years of legal battle was able to reserve a drainage area in a National Park?
3. Which cities have merely to pump water from large bodies of water nearby?

4. Which cities are more than one hundred miles from their source of water supply?
5. Which city was unable to get any surface supply of water?
6. Which of the cities receive their water mainly due to the force of gravity?
7. Which of the above cities have to pump their water to high altitudes in order to create pressure?
8. Which city is able to use the flow of its water to create electricity?
9. Which of the cities are entirely dependent upon mechanical pumps to send their water to their consumers?
10. Which of the cities will never have to increase their water supply to take care of an increased population if natural factors remain unchanged?
11. Group the cities into three groups according to the hardness of their water.

VERY HARD HARD VERY SOFT

12. Which of the above cities are forced to take water from a source that has previously been used to receive wastes?
13. Which cities have to contend with water borne diseases?
14. Which city has to contend with heavy mud and sand?
15. Which cities have an extensive chlorination process?
16. Which city has a large and complicated system of settling out sediment?
17. Which cities can use their water with little or no treatment?

PROBLEM II.

How do we get water into our homes?

Section A. Pumps.

Part 1. What pushes the milk you drink up the straw?

Put a tube ten to twenty inches long through a one hole stopper and fasten the stopper into a flask or bottle which has been filled with water. See Fig. 1.

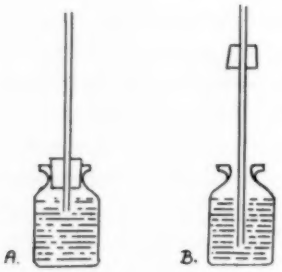

FIG. 1

Make certain the stopper is tight. "Draw" on the tube. Notice your success in getting water. Remove the stopper and insert the tube in the bottle so that the bottle opening is free to the air. Notice your success this time.

Experiment to answer the above question and put your answer or conclusion below.

When you say "suck on the straw" you give the wrong idea. Why?

Label and complete the drawing and add such details as are necessary to illustrate the force that " . . . pushes the milk you drink up the straw . . . "

Part 2. How does a simple pump work?

Complete the diagrams, Fig. 2, to show how a LIFT PUMP and a FORCE PUMP operate. (Remember to show what force **pushes the water up** the well shaft.) Consider that at A the piston is just starting its downward stroke and that at B it is just ending its upward stroke.

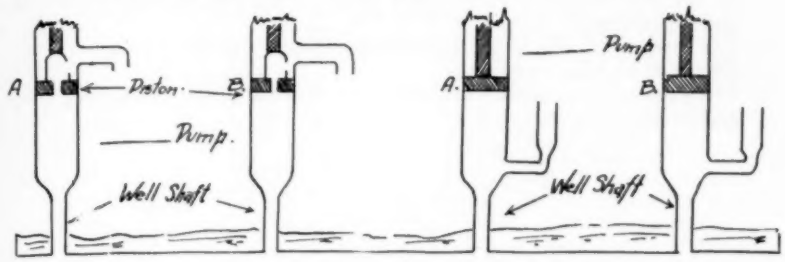

FIG. 2

Which type of pump might be used by the Wauwautosa Water Works Department to get their water to the surface?

Which type is used in a farm well twenty-five feet deep? Why?

Part 3. Read an outside reference on CENTRIFUGAL PUMPS. How do they work? (Drawings may help your explanation.) After reading problem I, where do you think centrifugal pumps might be used?

Section B. There are two types of faucets in common use in homes. The compression type faucet closes as the handle is screwed down and forces a washer over an opening like a vise screws up against a block. The fuller ball type has a lever attacked to the handle which pulls a ball into an opening to stop the flow of water. It closes with the flow of water; the other closes against the flow. Examine samples to find out how you can tell one type from the other without seeing the inner parts. How can they be told apart this way?

What type have you in your bathroom sink? kitchen sink? bath tub? laundry tub?

Can you replace a worn washer?

List all steps necessary for such a job. (For each type.)

Section C. How does water leave the house and go into the sewer without the sewer gas leaving the sewer and entering the house?

See the laboratory model of a water seal trap Fig. 3. Make one like it and experiment to discover how it lets the water out of the house but prevents the sewer gas from entering.

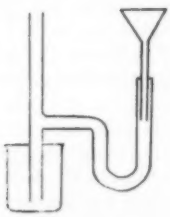

FIG. 3

Label and diagrams of the sink, bathtub, and toilet to show the following:

1. Water in the pipes as waste water is flowing out of the drain;
2. Water in the pipes after water has drained off (heavy cross-hatched lines will make this stand out from that in No. 1);
3. The air vent which allows air, and other gases to be diluted above the roof;
   (If the pipe were full of air could water enter? See problem I, unit II and explain below.)
4. The "soil pipe" which conducts the waste water to the sewer;
5. The flush pipe in the toilet;
6. The siphon in the toilet bowl. (Indicate where the short arm, long arm, and acting air pressure is.)

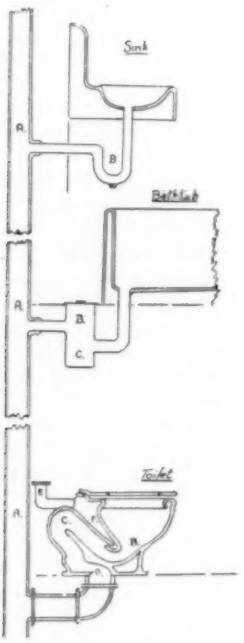

FIG. 4

Section D. How does Milwaukee pay for the water used?

Water is sold by the Water Department to those in and outside the city limits who may use it. As it flows into the consumer's premises it is measured by a meter and the consumer is charged according to the amount he uses. The rate within the city limits is 7 cents per one hundred cubic feet and beyond the limits 10 cents per one hundred. Seventy percent of the water consumers pay less than ten dollars a year.

See the sample meter dial, Fig. 5. Write on the line below the diagram the number of gallons it indicates having been used. Draw in the "hands" which would indicate that 709,146 gallons had been through the meter since it had been set at zero.

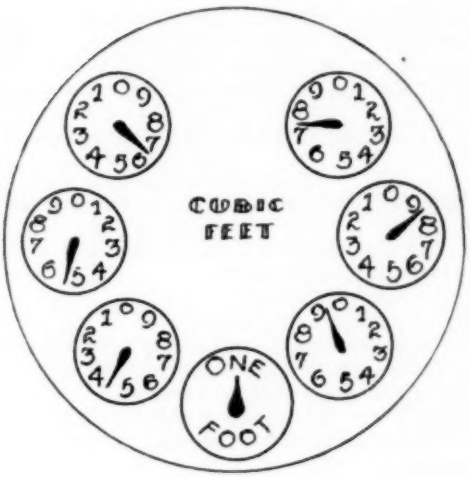

FIG. 5

RULE: "Start with the circle of lowest denomination (10) and read each circle using the lowest of the figures between which the hand points. When the hand is so near to a figure as to apparently indicate it exactly, refer to the next lowest circle, (for dial 1,000 to dial 100, etc.) and if the hand has passed the 0, the figure indicated is correct, otherwise take the next lower." The lowest dial is for test purposes and is not read for measure.

Copy or paste a water bill in the space below. Figure the cost of the water and write it below the bill. Show all work. WATCH OUT for the service charge.

PROBLEM III.

What is water?

Section A. In a sentence or two answer the problem.

Section B. DEMONSTRATION: Composition of water. (Electrolysis)

Set up electrolysis apparatus using tap water with a few drops of sulphuric acid. Use current from three or four dry cells. Allow the current to pass through the solution until there is sufficient gas in the bottles for testing.

1. Make a drawing of the apparatus.
2. What kind of current is used in this experiment?
3. What is the chemical formula for water?
4. How much more gas is there in one bottle than in the other?
5. Hold a glowing splint in the bottle with a smaller amount of gas. What happens?
   What gas is this?
6. Hold a lighted splint in the bottle with the larger amount of gas. What happens?
7. What happens when hydrogen is burned in oxygen?
8. Water is a combination of what two gases?

Section C. DEMONSTRATION: How does distilling purify water?

List of materials: 1. bunsen burner; 2. conductor tube; 3. boiler; 4. condenser; 5. collecting vessel; 6. water and impurities; 7. distilled water.

Make a drawing and label all parts with the names used in the list of materials.

List below the steps in the process and tell why the foreign matter is left behind.

Section D. DEMONSTRATION: Are there any impurities in distilled water?

Directions: Cover the bottom of a watch glass with a few drops of tap water and evaporate over a water bath.

1. Is there any deposit left behind?.....
2. Are there any impurities in tap water?.....

Repeat the same process only using distilled water this time.

1. Is there any visible deposit left behind?.....
2. Are there any impurities in distilled water?.....

(Note to instructor: Set up simplest possible apparatus for drawing and demonstration. A more elaborate set-up may be used if desired. Suggestion—Liebig condenser.)

Section E. DEMONSTRATION: What is the difference between hard and soft water?

Directions: Fill three test tubes half full of water: 1. Distilled water; 2. "Hard" water or Wauwautosa water; 3. Tap or Milwaukee water. Add a prepared soap solution drop by drop until suds appear. Shake vigorously after each addition.

1. How many drops of soap were added before suds appeared in the distilled water?.....
2. How many drops of soap were added before suds appeared in the hard water?.....
3. How many drops of soap were added before suds appeared in the tap or Milwaukee water?.....
4. Is water which forms a curd with soap, hard or soft?.....
5. What causes the "ring" you leave in the bathtub when you drain it after a bath?
6. Examine carefully the inside of your teakettle at home. What is the material coating the inside?
7. What is boiler scale?

(Note to instructor: To make hard water add a little bit of calcium chloride to the water.)

PROBLEM IV.

How is dangerous drinking water made safe?

Section A. 1. List several ways by which your water supply may be contaminated or polluted.
2. What precautions would a city have to take if its supply of water came from mountain streams?

Section B. 1. What methods for making water safe for drinking have you found to be used? (Add to this list as you study the unit.)
2. How is your water made safe for drinking?

Section C. DEMONSTRATION: How does chlorine make water safe for drinking?

Directions: Prepare three sterile covered dishes for the growth of bacteria. A mixture of several tablespoons of jello in about a quart of water to

which a glass of beef broth may be added, with a small quantity of baking soda may be used. This must be heated until the mixture is clear. Cover the bottoms of three dishes with this mixture.

1. In one dish, the control dish, put nothing.
2. Add a few drops of raw sewage to another.
3. Add a few drops of raw sewage, treated with chlorine, to the other.
4. What has happened to each dish?
5. What is the effect of chlorine on sewage?

(Note to instructor: Place all 3 in incubator for a long enough period to show the presence of living matter.)

PROBLEM V.

How may we keep our water supply pure?

Section A.
1. In what ways may a city or town dispose of its sewage?
2. How does Chicago dispose of its sewage?
3. How does New York dispose of its sewage?
4. How does Milwaukee dispose of its sewage?
5. How may you dispose of a small quantity of sewage at a summer cottage or farmhouse?
6. Make a drawing of a simple septic tank.
   a. What does sewage contain that makes it harmful?
   b. How does the septic tank help to remove this danger?

Section B. Milwaukee's sewage disposal plant.

What to do with 85 million gallons of sewage every 24 hours. This was a problem that confronted the Sewerage Commission back in 1913. After many years of experimenting and research which brought ideas from different parts of America as well as England the present plant was put into operation in 1925.

The plant at the present time serves approximately 700,000 people throughout what is known as the Metropolitan Sewage District of the County of Milwaukee. Before 1925 all the sewage from the city was allowed to run into three rivers which form the natural drainage basin for this region. Imagine the condition of these rivers and the lake with 85 million gallons of raw sewage being dumped in every day. Today all this sewage is brought to the sewage disposal plant on Jones Island by a system of sewers. The plant is located on the south side of the harbor entrance right where the sewage from the city was formerly poured into the lake.

The sewage that comes to the plant is run through a series of screens which remove the coarse particles. After the flow of sewage is slowed up, the heavier matter settles to the bottom of the grit tanks where it is removed and burned. The screened material now passing into a mixing chamber where activated sludge in the ratio of 25 percent to the volume of raw incoming sewage is mixed with the sewage. This then flows into aeration tanks.

Activated sludge is the solid matter that settles out of the purified sludge. This acts on the raw sewage like the addition of yeast to dough in making of bread.

In the aeration of the sewage, air is bubbled through the sewage which speeds up the process of purifying the sewage. The entire process of purification would take six weeks in an ordinary septic tank. The Milwaukee plant is really a large septic tank in which the processes are speeded up so that it takes but six hours.

After aeration the sewage is allowed to settle and the effluent, or water which is now freed of 98 percent of bacteria and 95 percent of the suspended solids, runs into the lake. The sludge which settles after aeration is dried and then sold as a fertilizer called "Milorganite."

The entire process of purifying Milwaukee's sewage is one of screening, aerating, or speeding up the bacterial action on the sewage, and settling. Instead of having to wait for six weeks for the sewage to purify itself, it now takes only six hours.

Section C. In what ways does Milwaukee attempt to make sewage harmless?

Demonstration: Secure samples of: 1. Raw sewage; 2. Sludge; 3. Effluent (water after settling).

1. What is raw sewage?
2. What is sludge?
3. What is effluent?
4. What is the chief feature of the Milwaukee Sewage Disposal Plant?

PROJECTS

1. Make a model of a filter using sand and gravel of various sizes.
2. Make a device out of tin cans for distilling water.
3. Give a complete report on the different types of pumps and their uses. Include models and drawings.
4. Report on the development of the activated sludge process of sewage disposal. Include any references to Milwaukee's lawsuit.
5. Report on the methods of distributing water in foreign countries. Include models on relief maps.
6. Give a report on "heavy water."
7. Make a map of Milwaukee County and show how it is drained.
8. Make a list showing in how many different ways water is used by man.
9. Make a report on other cities' water supply problems such as Los Angeles, New York, etc. More intensive reading will be required.
10. Make a model of the St. Louis water supply system station.
11. Make a model of Milwaukee's Sewage Disposal Plant.
12. Give a report on how Milorganite is made and what its properties are.
13. Report on the old Roman aqueducts and sewers.

After studying this unit you should know how to spell and use these words in sentences.

1. activated sludge
2. alum
3. aluminum sulphate
4. apparatus
5. aqueducts
6. aerated
7. artesian
8. bacteria
9. basin
10. borax
11. calcium
12. cesspool
13. centrifugal
14. composition
15. coagulate
16. crib
17. chlorine
18. cistern
19. community
20. conservation
21. cylinder
22. disease
23. dilute
24. disposal
25. distillation
26. drainage
27. evaporation
28. faucet
29. filter
30. filtration
31. germs
32. impervious
33. impurities
34. intake
35. insolvent
36. organism
37. palatable
38. polluted
39. potable
40. purification
41. reservoir
42. reclamation
43. septic tank
44. sediment
45. sewage
46. solvent
47. typhoid
48. washing soda
49. waste
50. watershed

THE ORGANIZATION OF HIGH SCHOOL BIOLOGY ON A SEASONAL BASIS

By Paul V. Beck
Central High School, Tulsa, Oklahoma

In the development of the ideal course in high school biology there must be a plan of organization so the materials of the immediate environment may be studied in the laboratory. The course must be based on Biological Principles. The materials used to illustrate these principles must be abundant at the time needed. The purchase of these materials is often impossible so they must be cheap. It must require a minimum of time in collecting. It must provide for study during the school year which comes mostly in the winter time. It should require fresh living materials at the time when they are the most interesting to study in that particular environment. It should be balanced in the various fields of Biology if it deserves the name of Biology.

It is easily seen that this plan must be tied up with the most universal and unchanging principle or natural phenomenon, "The Changing Seasons." It will be necessary to select for study from the most commonly found materials. Things studied must be found in all habitats at the same time and doing some things in common. The name of the course is not important, but for lack of a better name I have selected the name, SEASONAL BIOLOGY.

Let us now see how this course will arrange itself in actual practice. School begins in September and closes in May or early June. We must hurry or some of the most important living things will be gone. There is no time to lose in the fall. Insects are still abundant and have just about finished some of the farmer's crops. They have even eaten the leaves of some of our trees, or perhaps have buried themselves in their trunks or fruit. Other insects have not only pollinated our flowers but have stored up some winter food and we may have a part of it to pay for the house we built for them. Some insects prefer to live alone but others live in colonies. There are some insects that live on other insects. But the insects that lay their eggs in the rain barrel or garbage can are enemies in a different way. Most insects are important on account of what they eat. They solve their food problem in their own way. We sometimes try to keep them in control by feeding them certain insecticides.

Can we feed them all the same kind of insecticide? Maybe we had better examine their mouth-parts to see if they will all eat our poison.

The food-problem is universal for plants and animals. Where does the world's food come from? The answer is, the leaves of plants. This is the best time to study leaves. They have made their food for the tree and are about to be cut off to save water for the tree. Photosynthesis is very important. Why not study it now when we are collecting leaves? Those autumn colors are now attracting everybody's attention. It would be interesting to make a collection of leaves or leaf-prints. The food made in the leaf is mostly stored in the seed. Now is a good time to study the seeds and why not use corn and beans as they illustrate different groups of plants? If these are planted in the sand, they grow into seedlings where the stems may be studied along with the roots. Various experiments to see what is required for seeds to grow may be performed. Do they need oxygen? How does this compare with the needs of the leaf? Under the stem study may be included budding and grafting by stems or this may be left for the spring when reproduction is studied. Certainly, forestry and our lumber supply should be given at least a passing notice. Not all trees lose their leaves. It is winter now. The evergreens show up and we are anxious to know some of the different kinds. Collections of woods, nuts, acorns, garden seeds, weed seeds, winter buds, types of roots and underground stems may be made. The storage of food as found in the white potato or carrot will again bring back the food problem.

We have now come to our third six weeks. Health problems begin to interest us. The chief one of these is our food problem. What kinds of food have we? Let us test for different kinds of food. We are reminded of where this food was made and how it was made. Now we are to study how it is prepared for digestion by the teeth. The organs of digestion with their digestive juices containing enzymes may be illustrated by experiments on foods in the laboratory. We need to know something about vitamins. It may be possible to experiment a little on some of them. The "Hunger Fighters" should receive some thanks for the good they have done.

The digested food must be absorbed and then carried to the parts of the body by the circulatory system. The food is used by the body for growth into the various body tissues and for energy. In order to get this energy out of the food, we need

oxygen. The respiratory system may be illustrated by the lungs of a calf or pig secured from a packing plant. Certain glands secrete hormones that influence metabolism and other bodily functions. The animal furnishes the materials for this study, or charts, models, and a human skeleton may be available. The first semester ends.

A new semester begins. For those just beginning Biology, they start here. It is still winter. Outside life is not yet challenging. Health problems are still uppermost. We must take note of the tiny organisms called Bacteria and Protozoa which have much to do with some of our common diseases. Before we study these, we must learn to use the compound microscope. We begin by using some small plants that grow on the north side of trees, the Pleurococcus. We may also be able to find some Spirogyra growing in a protected spring. The Elodea may be found in fish ponds. The hay-infusion will start to growing millions of Protozoans in a short time. The yeast and bread mold may be used to illustrate plants without chlorophyll. Cultures of Bacteria may be grown from milk, dust, face-powder, hair, or some other suspected place. The autoclave will be used in preparing the culture of agar-agar to sterilize it. Disinfectants and preservatives may be tested as to their effectiveness. If we need an incentive for this study, there may be an epidemic of colds or Diphtheria. The famous "Microbe Hunters" should receive some time in grateful praise for their contributions. The theory of spontaneous generation has been exploded in our own laboratory.

Six weeks of time have slipped away. Spring is about here again. Students and teacher are tired of staying inside. Why not start watching for the return of birds and keep a chart as to the dates first seen? Only one day a week will be needed for this. For laboratory study, the plants are more easily brought to the laboratory at this season. How shall we organize this mass of material? We must group it under Biological Principles. We must follow some definite course and know where we are going so the students can follow. The principles must be common to all life. Why not use the Biological Principle of Reproduction to tie this all together? Let us see if this is inclusive enough for all we want to study. The moss plant is easily found and studied just to see its method of reproduction. The fern can now be found to illustrate the next step. The pine is easily found with some cones for a brief study. And now the flowers are about to

appear. Buds are bursting. Perhaps we had better take time to study fruit buds now. When the flowers come, we find the first one and study it to learn its parts and the use of each part. Pollination and fertilization are best studied now. Some of our insect friends come again and we take note of some of the ways they are adapted for cross-pollinating flowers. There will be hobbies among the various class members now. Wild flowers for some, cultivated flowers for others, tree flowers for a third group, and blooming shrubs may interest the rest. Mendel's laws can best be taught here.

The last six week period has now arrived. We have paid little attention to the animals so far except for the birds once a week. In watching the robin eat, we become interested in the earthworm and decide to study it along with some other worms. The crayfish seems rather busy and maybe some boy finds one with a mass of eggs held under the telson. We watch them emerge as young crayfish and learn to appreciate some of the life-functions of the crayfish. The fish is brought to class by some angler and we begin the study of vertebrates. Some frog eggs are found and they soon hatch into tadpoles. Now would be the best time to find out about the frog in general. Snakes, turtles, and lizards may be included in our study of methods of reproduction. The bird is now making, or has already made, a nest and the young are found. Reproduction is the opening for a study of the bird in detail as time permits. Some young rabbits are found and we may use them for a beginning of the study of mammals. Our study of the animal kingdom has been somewhat hasty but it has been in a definite order. We have used the materials available in every community. Perhaps the student has been thinking of his own heredity during all this process. In the High School some place should be given some good suggestions as to the improvement of the human race through the improvement of its heredity. Some students might be interested in tracing their own family tree. The course of beginning Biology for High School students has begun and ended with a study of Biological Principles. The emphasis has always been on the relation to man, sometimes physiologically, and sometimes economically, and again aesthetically.

In this organization, a minimum of preserved material has been necessary. Collections of materials studied may serve to tie the course in with the community and the outside environment. These may lead to a better appreciation of the fauna and

flora ever increasingly important in our modern life with an abundance of leisure time. The course is continuous and unified. Consideration is taken of the dominant interest of the student at the time. The individual organism is not torn up into a dozen fragments to suit a particular course of study *artificially created and maintained*. The laboratory materials dominate the course. The textbook will become the reference book to find the answers to questions that would take too long to find by experiment and research. STUDY NATURE NOT BOOKS, has been our motto. May I add that I have personally used this plan of organization for a number of years and find it is liked by students. To summarize the various topics studied, they are briefly stated again:

1. Insects are both friends and enemies of man's food supply.
2. The living plant makes and stores the food of the world.
3. Our food problem is also a health problem.
4. Some small organisms also affect our health.
5. Plants and animals have very interesting methods of reproduction.
6. Biological principles are important to the human race.

RELATING HIGH SCHOOL PHYSICS TO THE ENVIRONMENT

By Wm. H. Brown

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Teachers of high school physics are rapidly discovering that the average pupil is far more interested in understanding the phenomena of everyday life and acquiring a knowledge that will allow him to use the principles of physics in an interesting or serviceable way than he is in becoming a physicist. Textbook writers realizing this have done much, though hardly enough, to meet this growing attitude. There is evident an effort to use illustrations that are recent enough not to be ludicrous; and instead of the most exclusive use of abstract figures and drawings, the principles of physics are illustrated by photographs of concrete things and of real situations.

Several years of experience in teaching high school physics have confirmed one very definite impression—that students introduced to a new subject which arouses their interest begin

at once to find more or less related material in nearly every book, magazine, and newspaper that they pick up and in the common things about them. Almost every article or picture speaks to them, in some measure, in terms of this new interest. Material pours in to the teacher and fairly begs to be used in some way. The teacher with even meager resourcefulness can take advantage of this natural situation to keep his bulletin board and his museum table in constant use. Suggestions for their uses originate in the class with the slightest hint from the teacher. Too much suggestion from the teacher would spoil the fun of being original and sometimes discourage an idea much more clever than the teacher has in his bag of tricks.

The bulletin board is now quite generally accepted as part of the standard equipment of the modern classroom, and the proportion of bulletin board space to blackboard space is increasing; so this paper assumes that a degree of use is being made of the classroom bulletin board. Articles have appeared evidencing its skillful use. There is, however, evidence of much improper use and, worst of all, lack of use of this very useful device. Questions raised by many teachers, cadet and veteran, indicate that interest in bulletin boards is at a peak and that sources of information on the proper use of the bulletin board are meager. The difficulty seems to lie in the fact that teachers who are skillful with bulletin boards have written too little that might be helpful to the beginning teacher and have perhaps delayed the information of a general philosophy and general procedures.

The purpose of this paper is to set down a few experiences with bulletin boards and museum collections as a part of the teaching technique in high school physics, and to suggest similar articles from other teachers with a view toward hastening the development of a general philosophy that will direct us in skillful use of these two new and related devices. The experiences represent pupil activity and pupil resourcefulness leading to mastery of course material.

In a unit on electricity after parallel and series connections had been presented, a group of pupils arranged pictures of electrical measuring instruments, cells and bells on the bulletin board and made the proper connections with white thread made stiff with starch. The pictures were cut from magazines and mounted on black construction paper. The separate posters were arranged in an attractive manner. The neat and unusual display served to attract the pupils and made the desired im-

pression. The legend "Connections" in series was cut from black construction paper and mounted on a white background. A bit of humor was introduced by including a group of circus elephants connected in series from trunk to tail.

A bulletin that seemed to appeal particularly to girls was exhibited after a study of the cost of electrical power. It was captioned "What Price Servant." The arrangement consisted of pictures of common electrical devices found in the average home with the cost per hour for each appliance indicated. The cost was calculated from the data given on the appliance. The exhibit shifted the value of the calculation to the foreground and left the calculation itself in the background.

This paper suggests that the bulletin board and museum table be the property of the class rather than of a committee of the class since each pupil should be learning to act as well as think, as well as do older scientists on such matters. The classroom museum table and bulletin board are the pupil outlets for findings comparable to the state museums and pictorial magazines of the adult scientist. Pupils are fascinated by this corner of the classroom and enjoy making it bright and instructive. They develop at the same time such qualities as cooperation, leadership, judgment of good work, appreciation of balance, neatness, and many other desirable traits and attitudes.

The subject of the classroom bulletin board and museum table has had very little discussion in educational literature and the field offers interesting opportunity for experimentation. Problems such as the reliability of test bulletins, their value as drill devices and the disposition of bulletin and museum material after display should present interesting solutions.

DETAILS OF NEW SOVIET SKY-GIANTS

First scanty details of the design of the sixteen giant airplanes which will take the place of the ill-fated "Maxim Gorky" have been released by the Soviet Government.

The new planes will be of the all-metal monoplane type powered by six engines, each of 1,200 horsepower. The Maxim Gorky had eight engines of 850 horsepower each.

Designed to carry from 60 to 70 passengers, the new planes will have a top speed of 167 miles an hour.

The wing span of each "ship" will be 206 feet, the over-all height 36 feet, the length 111 feet and the distance between the landing wheels 34 feet.

As planned the new airplanes will operate in horizontal flight, at normal load, with two of the six engines out of order. Robot pilots, blind-flight instruments and equipment for night landings will be provided.

LABORATORY PROCEDURES

By Ernest E. Bayles
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Fifty or seventy-five years ago when educational leaders, such as former president Eliot of Harvard, were persistently campaigning for recognition of the sciences in high school and college, one of the most effective arguments was that by means of the laboratory students could be given a grasp of the scientific method such as they could get in no other way. But the results up to now have hardly vindicated such a view. Classes which involve work in the laboratory seem today to be no more effectual in promoting the scientific attitude, or mind texture, than classes which include no laboratory at all.

The reason is probably not hard to find. Scientific-mindedness is not something which is peculiar to the science laboratory. It is neither to be found only in the laboratory, nor is it always to be found there. Scientific-mindedness is, or should be, a generalized attitude of mind. It is not something to be practiced within the four walls of the laboratory and then put aside, with the apparatus and materials, when one leaves for the day. Scientific-mindedness is to be cultivated in all phases of the science classroom, as well as in all phases of all classrooms. Scientific-mindedness means that one possesses the ability and disposition to use the scientific method in any and all pursuits after knowledge, whether these pursuits be for a new chemical compound, for a new mathematical formula, for a new heavenly body, for a new bacterium, or for a new hat or necktie. The scientific method is a method of obtaining tested knowledge, and is appropriate whenever and wherever tested or dependable knowledge is needed. It may be that the most promising aspect of the New Deal, in so far as it is such, is the disposition to attack governmental problems experimentally. Otherwise, how can progress ever be made at solving the tremendous governmental problems which confront us?

It is difficult to see why anyone should be surprised that laboratory classes, as they are usually conducted, are no more fruitful at making students scientifically minded than they are. It is surprising that anyone should ever have thought that they would be. As the laboratory period is conducted in the majority of cases, the student enters the room equipped with a set of instructions which are to be followed in the minutest detail.

An excuse for the minuteness of instructions is that injury to life, limb, or property may come from disregarding them. This is hardly justification, however, for giving the student no opportunity to participate in planning what he shall do in the laboratory.

In order to believe that procedures, planned entirely in advance by the teacher or the writer of the manual, are conducive of the scientific attitude of mind, one must assume that they involve separate activities of a so-called "scientific" nature—activities which the scientist performs. One must also assume that the mere performance of these separate activities will be sufficient for establishing them in the behavior of the student, and that after the separate activities have been learned, they will, somehow or other, band together into a sufficiently coordinated hierarchy to be called scientific procedure. For example, ability to observe closely is one of the important qualities which must be possessed by any scientist. The biology course is therefore thought by some to afford excellent training in the scientific method because in it are included hours upon hours of observational work, during which the student peers through a microscope and records with greater or lesser veracity what he sees. Such practice in observation, it is argued, trains the general observational powers of the pupil so that he may become therefore a good observer. Since the scientist must be a good observer, the student is thus on his way to becoming a good scientist.

It is probable that not many present-day teachers believe in such a view when it is stated in this manner. One is inclined to say, however, that if teachers do not hold such a belief, why do they keep talking as if they did? It is possible, for example, that one can find at one place or another in the majority of biology textbooks now available, the statement that one of the advantages of a thorough course in biology is the training which the student receives in the powers of observation. Formal discipline was quite thoroughly debunked thirty years ago, but the view is actively influential today as is evidenced by statements and beliefs such as these. To believe that generalized improvement of one's observational powers will come from peering through a microscope in a botany laboratory is to believe in the legerdemain of formal discipline and faculty psychology. It is small wonder that laboratory work which is conducted upon the basis of such a pedagogical theory, as is much of our present laboratory work, is a complete failure.

If the laboratory is to contribute toward making students more thoughtful and self-reliant, it must be conducted so as to furnish opportunities for solving challenging problems thoughtfully and with self-reliance. It is true that the housewife employs thoughtfulness and self-reliance of a kind when she goes into the kitchen and proceeds to follow successfully a recipe which has been dictated to her over the radio or in a current magazine. In order to do that, she must be able to listen or read intelligently, and, for most recipes, must have sufficient familiarity with cooking to do considerable "reading between the lines."

But the real essence of scientific-mindedness is the ability to *make* the recipe rather than to *follow* it. To change the metaphor, it is the ability to blaze trails rather than to follow those already blazed. It is the ability to be a Galileo, a Newton, a Pasteur, or an Einstein, rather than to be merely a humdrum, routine worker in the laboratory. The latter may be a skilled workman, but the former is a creator and a genius.

The objection will be made, of course, that it is absurd to harbor such ambitions in connection with anything that may be done in a high school or junior college science laboratory. It will be argued that geniuses are born, not made, that they appear no oftener than once in a lifetime, and that it is completely absurd to expect to make geniuses out of laboratory students. This may all be true. The entire objection may be granted if the term genius is to be applied only to an individual who makes brand new discoveries which have the significance of those of Newton or Einstein. But what is it that distinguishes the human mind most surely from the brute mind if not the creative feature which is the essence of genius? If laboratory classes are to contribute in the highest possible degree toward making human beings *more human*, more creative, they must be made to afford the pupil repeated and continual opportunities for the practice of creativeness and self-reliance.

There are, in general three major points of view in educational theory—the autocratic, the *laissez faire*, and the democratic. From the autocratic point of view, the science laboratory is to be envisioned merely as another pedagogical device whereby predigested subject matter can be imposed upon the mind of the student. It is merely another aid for preparing the student to take the examination. It represents another avenue of approach whereby new ideas may be shunted into the student's thinking. The idea of the teacher as perpetrator and the

student as recipient is paramount in any autocratic scheme.

According to teaching philosophies which are basically autocratic or propagandic in nature, the laboratory can well be conducted upon the recipe-learning basis. Since the laboratory is to serve as a means for promoting more thorough learning of a completely teacher-planned arrangement of subject matter, it follows logically that a laboratory period which moves forward with clock-like precision is the ideal. No casting about for possible plans in such a class. No foolish frittering with false leads. Decide what is to be done and move straight toward the mark. Business efficiency must reign. The carefully prepared guide sheet and laboratory manual, which tell the student exactly what he must do, are in complete accord with the autocratic or propagandic philosophy of teaching.

The *laissez faire* view of teaching implies the opposite form of management of the laboratory. It means the absence, or the minimum, of teacher domination. It means that the student will be permitted to do virtually as he wishes in the laboratory so long, supposedly, as he does not become wantonly destructive. The *laissez faire* plan implies extensive use of the laboratory; in fact, far greater use than does traditional teaching. The very fact that the older of the so-called "progressive" schools have been commonly known as "activity schools" is evidence of the close link between Progressivism and an increased use of laboratory teaching. Give the student an opportunity to be active, for in so doing you will hasten his learning surprisingly. This is a fundamental dictum of the teacher who believes in *laissez faire* progressivism.

But the idea of pupil activity is secondary in *laissez faire* progressivism to the idea of pupil-purposing—the notion that the pupil must decide what he will do and when. Thus, much of value in activity school programs has been vitiated by the pointlessness of activities which are carried out merely as ends in themselves and therefore often lead nowhere educationally. One may believe thoroughly in the desirability of an active child in the classroom and that so far as the pupil is concerned, the activity may be considered as an end in itself. But it appears only reasonable to believe that the teacher must, at the same time, make sure that educationally desirable outcomes will accrue in greater degree from such activities than from traditional procedures.

Whether he intends it or not, the teacher is bound to be in-

fluential in determining what activities the pupil will choose. One would hope, therefore, that the teacher would be influential in turning the balance in favor of activities which lead to enhanced understandings and heightened appreciations of significant matters. Laboratory for the sake of activity, possibly, so far as the student is concerned; but laboratory for the sake of enhanced educational outcomes, so far as the teacher is concerned!

What, therefore, is the place of the laboratory in a scheme which prepares the student most effectually for intelligent participation in a democratic society? An individual so prepared must be intelligently independent or scientifically minded, at least in so far as his capacities will allow. In order to answer this question, therefore, one may well look at the place which the laboratory occupies in the procedures of a scientifically minded man—a scientist. The scientist does not go into the laboratory merely to occupy time. The laboratory is not for him a "daily dozen" or a period for calisthenics, either physical or mental. The scientist goes into the laboratory when, and only when, the laboratory furnishes the best means at his command for solving an unsolved problem.

Struggling with a problem, the scientist looks for, and sooner or later formulates, a possible answer. The answer looks sound, according to his own thinking, and according to available literature. He must therefore put the answer to the supreme test of nature, and so he enters the laboratory.

In like manner should the pupil be brought to wrestle with a challenging problem; brought to study available literature dealing with the problem; and then encouraged to go into the laboratory in order to subject his answer to the supreme test of nature. The laboratory will thus progressively come to assume in his thinking its rightful place in scientific or thoughtful procedures, and the pupil will come more fully to appreciate the function of the laboratory in the quest for knowledge. In the laboratory, the student rubs against the brute realities of nature and develops a genuine appreciation for the tough, resistant character of facts themselves; a realizing sense of things in the rough which books cannot possibly afford.

In the ordinary science classroom of today, where thirty or forty students are brought together for an hour a day, five days a week, the idea of taking the class into the laboratory only when a problem demands it is a dream rather than a reality.

But it is a dream which can serve as an ideal toward which the science teacher may forever strive. Practically, the laboratory manual should possibly first be placed in the hands of every student, and generally suitable experiments or exercises chosen for all. Then, however, the teacher will need to study the needs and interests of each and every student in order to get as many as possible interested in particular laboratory projects of their own—projects which will involve careful and extensive thought, organization, and imagination on their part; projects which will enable them, at opportune times, to make special contributions to the general work of the entire class. Once a student "catches fire" and starts work on such a project, he can and should be excused from the performance of the regularly scheduled exercises or experiments until his own special project is completed.

If the laboratory is to be made really educative, it must be something more than merely a place in which to spend two or more hours a week in order to relieve the tedium of daily recitation. It must afford the pupil opportunity to do something more than merely follow the cut and dried instructions furnished by a laboratory manual. To make the laboratory contribute to the development of thoughtfulness and self-reliance on the part of the pupil, continuous opportunities must be afforded for the practice and use of thoughtfulness and self-reliance. Experimental studies of laboratory procedure, especially those of Horton[1] and Beauchamp,[2] have given ample indication that the only way to enhance the resourceful qualities of a pupil is to confront him repeatedly with situations or problems which elicit resourceful effort on his part. Until the laboratory is made into a place where active thinking is demanded and achieved, the laboratory will fail to make any significant contribution to the development of scientifically-minded students.

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[1] Horton, Ralph E., "Measurable Outcome of Individual Laboratory Work in High School Chemistry," Teachers College Contributions to Education, No. 303.

[2] Beauchamp, R. O., and Webb, H. A., "Resourcefulness an Unmeasured Ability," SCHOOL SCIENCE AND MATHEMATICS, Vol. XXVII, pp. 457–65; May 1927.

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A METRICAL ANALOGY BETWEEN THE TRIANGLE AND THE TETRAHEDRON

By Roy MacKay

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Although volumes have been written on the geometry of the triangle comparatively little has been written in English on its three dimensional analogue, the tetrahedron. In the usual course in elementary solid geometry one seldom goes beyond the theorems concerning the insphere and the circumsphere in the geometry of the tetrahedron in spite of the numerous other analogies. While it is the purpose of this paper to compare a metrical property of a point on the Euler line of a triangle with a similar property of a point on the corresponding line of a tetrahedron, we begin with a review of a few of the simple though not generally known properties of a tetrahedron.

Corresponding to the theorem that the perpendicular bisectors of the sides of a triangle are concurrent at a point equidistant from the vertices of the triangle, there is the following theorem which we state without proof: The six planes bisecting the edges of a tetrahedron at right angles are concurrent at a point equidistant from the vertices of the tetrahedron. This point is called the circumcenter of the tetrahedron.

In a triangle, the medians are concurrent at the centroid, a point two-thirds of the distance from a vertex to the mid point of the opposite side. In a tetrahedron, the six median planes each determined by an edge and the mid point of the opposite edge are concurrent at a point three-fourths of the distance from a vertex to the centroid of the opposite face and half-way between the mid points of opposite edges.

Proof: Let M_{ij} be the mid point of the edge A_iA_j of the tetrahedron $A_1A_2A_3A_4$ and let G_i be the centroid of the face opposite A_i ($i \neq j$, $i, j = 1, 2, 3, 4$). The triangle $A_1A_3M_{24}$ (fig. 1) is in one of these six planes and if we draw $M_{13}K$ parallel to A_1G_1 to meet A_3M_{24} at K, it is evident that $A_3K = KG_1 = G_1M_{24}$, in view of the property of the centroid of a triangle. Denote the intersection of A_1G_1 and $M_{13}M_{24}$ by G, then $M_{13}G = GM_{24}$ and $GG_1 = \frac{1}{2}M_{13}K$. But in triangle $A_1A_3G_1$, $M_{13}K = \frac{1}{2}A_1G_1$. Therefore G bisects the distance between M_{13} and M_{24} and it is three-fourths of the distance from A_1 to G_1. To show that G is common to all six planes, we first observe that being on A_1G_1 it is common

to three of the planes and being on $M_{13}M_{24}$ it is common to a fourth. G is also on the plane determined by A_3A_4 and M_{12} for the diagonal of the parallelogram $M_{12}M_{13}M_{34}M_{24}$ is bisected at G. Similarly G is on the sixth plane, and a similar analysis demonstrates that the point G is the mid point of the line segment joining the mid points of any pair of opposite edges and that it is three-fourths of the distance from any vertex to the centroid of the opposite face of the tetrahedron.

The four concurrent lines $AiGi$ $(i=1, 2, 3, 4)$ are called *medians* of the tetrahedron, and the three concurrent segments joining the mid points of pairs of opposite edges are called *bimedians*. The point common to these seven lines is the *centroid* of the tetrahedron.

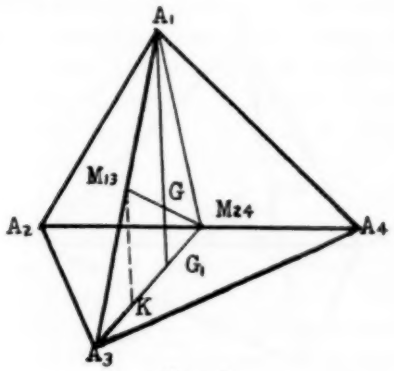

FIG. 1

In a triangle the orthocenter, centroid, and circumcenter lie on the Euler line and the centroid is two-thirds of the distance from the orthocenter to the circumcenter. The general tetrahedron does not have an orthocenter for it is only in very special cases that six altitude planes can be passed through the edges of a tetrahedron perpendicular to the opposite edges. Gaspar Monge (1808) suggested the following theorem as an analogy to the altitude theorem of the triangle: The six Monge planes, one through the mid point of each edge of the tetrahedron perpendicular to the opposite edge are concurrent at a point which is symmetric to the circumcenter with respect to the centroid. The line containing these three points is called the *Euler line* of the tetrahedron.

Proof: Let O and G be respectively the circumcenter and centroid of the tetrahedron $A_1A_2A_3A_4$ (fig. 2). Suppose the plane

through M_{13} perpendicular to A_2A_4 meets OG at H. Pass a plane through G perpendicular to A_2A_4. Since O lies in the plane perpendicular to A_2A_4 at the mid point M_{24}, these three parallel planes (each perpendicular to A_2A_4) intercept equal segments on the bimedian $M_{13}M_{24}$ and hence make $OG=GH$. That is H is symmetric to O with respect to G. Similarly the five other planes determined by the mid point of each of the other edges and the opposite edge meet OG at H.

The point H is called the *Monge point* of the tetrahedron or the *orthomedial center*. It is the center of an equilateral hyperboloid of one sheet. The four altitudes of the tetrahedron (i.e. the line segments drawn from a vertex perpendicular to the opposite face) are rulers of this surface. In the special case men-

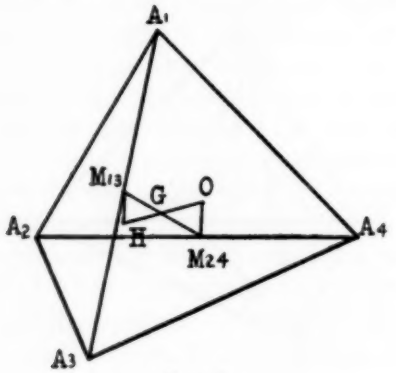

FIG. 2

tioned above wherein opposite edges are perpendicular, each of the six Monge planes contains an edge, two altitudes, and the common perpendicular to a pair of opposite edges of the tetrahedron. The hyperboloid degenerates into a cone and its vertex H becomes the point of intersection of the four altitudes as well as the three common perpendiculars to pairs of opposite edges. These common perpendiculars are called *bialtitudes*. The tetrahedron is called orthocentric in this case and it is interesting to note that the feet of the altitudes are the orthocenters of the faces to which they are drawn. Court gives an excellent bibliographical reference for the study of the orthocentric tetrahedron in the October 1934 issue of the *American Mathematical Monthly*.[1]

[1] Court, N. A., "Notes on the orthocentric tetrahedron," *Am. Math. Monthly*, Oct. 1934, p. 499.

In any triangle the distance from the orthocenter to a vertex is double the distance from the circumcenter to the mid point of the opposite side. The quadrilateral $OM_{13}HM_{24}$ (fig. 2) is a parallelogram for its diagonals bisect each other. Hence, in any tetrahedron, the orthomedial center is the same distance from the mid point of an edge as the circumcenter is from the opposite edge. In general there is no simple arithmetic ratio between the distance from H to a vertex and the distance from O to the opposite face.

In a triangle the square of the length of a median equals one-half the sum of the squares of the sides issued from the same vertex diminished by one-fourth of the square of the other side; and the sum of the squares of the distances from the centroid to the vertices is one-third of the sum of the squares of the sides. In a tetrahedron, corresponding relationships are more easily stated if we adopt the notation that S_i equals the sum of the squares of the edges concurrent at A_i and S_i' is the sum of the squares of the three edges not meeting at A_i. Denote the sum of the squares of all edges by $S_i+S_i'=S$. Then,

(1) $$A_iG_i^2=\tfrac{1}{3}S_i-\tfrac{1}{9}S_i',$$

(2)[2] $$\sum A_iG^2=\tfrac{1}{4}S,$$

(3)[2] $$M_{ij}M_{kl}^2=\tfrac{1}{4}S-\tfrac{1}{2}(A_iA_j^2+A_kA_l^2),$$

(4)[2] $$\sum GM_{ij}^2=\tfrac{1}{8}S.$$

The proof of (1) was given in the problem section of this journal[3] and the proof of (2) follows very readily from it after making the substitution that $A_iG=\tfrac{3}{4}A_iG_i$ and adding the squares of the four such expressions.

Since GM_{13} (fig. 2) is a median of the triangle A_1GA_3,

$$GM_{13}^2=\tfrac{1}{2}A_1G^2+\tfrac{1}{2}A_3G^2-\tfrac{1}{4}A_1A_3^2;$$

likewise,

$$GM_{24}^2=\tfrac{1}{2}A_2G^2+\tfrac{1}{2}A_4G^2-\tfrac{1}{4}A_2A_4^2,$$

and four other equations of this type may be written. Adding the equals of these two equations and applying (2), there results

$$\tfrac{1}{2}M_{13}M_{24}^2=GM_{13}^2GM_{24}^2=\tfrac{1}{2}(\tfrac{1}{4}S)-\tfrac{1}{4}(A_1A_3^2+A_2A_4^2),$$

which is essentially the result in (3). If all six such equations are added, we obtain

$$\sum GM_{ij}^2=\tfrac{3}{2}\sum GA_i^2-\tfrac{1}{4}S=\tfrac{1}{8}S.$$

Corresponding to the triangle theorem that the sum of the

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[2] The summation sign $\sum$ implies that all four, or all six such expressions are to be added. The subscripts *ijkl* represent a permutation of the numbers 1234.

[3] School Science and Mathematics, June 1934, p. 668.

medians is less than the sum of the sides but greater than three-fourths of their sum, Court has proposed two very interesting theorems stating that the sum of the medians of a tetrahedron is greater than four-ninths but less than two-thirds the sum of the edges; and the sum of the bimedians is less than one-half and greater than one-fourth the sum of the edges of the tetrahedron.[4]

In a triangle the square of the distance from the orthocenter to a vertex is four times the square of the circumradius less the square of the side opposite that vertex; and the sum of the squares of the distances from the orthocenter to the vertices of the triangle is equal to twelve times the square of the circumradius less the sum of the squares of the sides of the triangle. In a tetrahedron of circumradius R,

(5) $$HA_i^2 = \tfrac{1}{4}(4R^2 + S_i - S_i'),$$

(6) $$\sum HA_i^2 = 4R^2,$$

(7) $$HM_{ij}^2 = R^2 - \tfrac{1}{4}A_kA_l^2,$$

(8) $$\sum HM_{ij}^2 = 6R^2 - \tfrac{1}{4}S.$$

Proof: (fig. 3) $HM_{13}^2 = OM_{24}^2 = R^2 - M_{24}A_4^2 = R^2 - \tfrac{1}{4}A_2A_4^2$. Similarly six other expressions of this type may be obtained and adding them completes the proof of (7) and (8). In triangle HA_1A_3, HM_{13} is a median, hence the expression for the square of the median HM_{13} leads to the equation,

$$R^2 - \tfrac{1}{4}A_2A_4^2 = \tfrac{1}{2}(A_1H^2 + A_3H^2) - \tfrac{1}{4}A_1A_3^2.$$

Addition of the six such expressions gives the result desired in (6).

Before obtaining the proof for (5) it is interesting to consider still another analogy between the triangle and the tetrahedron. If P is a point on the Euler line of a triangle one-kth of the distance from the circumcenter O to the orthocenter H,

$$OP^2 = (9R^2 - S)/k^2,$$

where R is the circumradius of the triangle and S is the sum of the squares of its sides.[5] In a tetrahedron, if P is a point one-kth of the distance from O to H,

(9) $$OP^2 = (16R^2 - S)/4k^2.$$

Since $OP = OH/k$, let us first find OH_2. From the median relationship in triangle A_1OH, (fig. 3)

(10) $$A_1G^2 = \tfrac{1}{2}A_1H^2 + \tfrac{1}{2}R^2 - \tfrac{1}{4}OH^2.$$

Addition of the four such expressions gives, after substitution from (6), the result

[4] *Am. Math. Monthly*, May 1934, p. 338; and Sept. 1933, p. 435.

[5] Johnson, R. A., *Modern Geometry*, p. 175.

(11) $$OH^2=\tfrac{1}{2}(16R^2-S).$$

Divide by k^2 and the proof of (9) is complete. It is now easy to establish (5), for applying (11) and (1) to (10) yields the desired expression for the square of the distance from the orthomedial center to the vertex A_i.

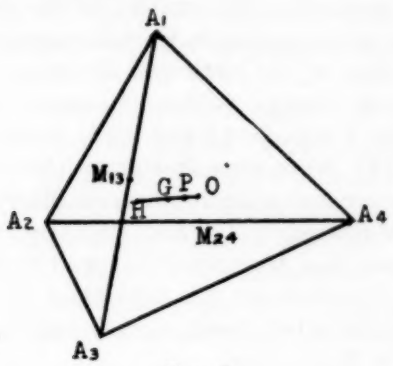


FIG. 3

If P is a point on the Euler line of the triangle $A_1A_2A_3$ one-kth of the distance from the circumcenter O to the orthocenter H,

$$PA_i^2=\{(k-3)^2R^2+(k-1)S-kS_i\}/k_2,$$

and

$$\sum PA_i^2=\{3(k-3)^2R^2+(2k-3)S\}/k^2,$$

where S_i is the square of the side opposite A_i, S is the sum of the squares of the sides, and R is the circumradius of the triangle.[6] If P is one-kth of the distance from O to H in a tetrahedron,

(12) $$PA_i^2=\{4(k-2)^2R^2+2kS_i-S\}/4k^2,$$

(13) $$\sum PA_i^2=\{4(k-2)^2R^2+(k-1)S\}/k^2,$$

(14) $$\sum PM_{ij}^2=\{24(k-2)^2R^2-(k^2-6k+6)S\}/4k^2.$$

Proof: By the law of cosines applied to the triangles HPA_1 and OPA_1 (fig. 3) one obtains the expressions:

$$A_1H^2=A_1P^2+(k-1)^2OH^2/k^2-2A_1P(k-1)(OH/k)\cos HPA_1,$$

$$OA_1^2=R^2=A_1P^2+OH^2/k^2-2A_1P\cdot(OH/k)\cos OPA_1.$$

Angles HPA_1 and OPA_1 are supplementary (or equal, if P divides OH externally) so their cosines may be eliminated from these two equations by multiplying the equals of the second by $k-1$ and adding to (or subtracting from) the first. The application of (5) and (11) to this equation establishes (12) while the sum of the four such expressions results in (13). In the triangle

[6] See Prob. 1338, SCHOOL SCIENCE AND MATHEMATICS, Oct. 1934, p. 771.

A_1PA_3, PM_{13} is a median and can therefore be expressed in terms of A_1G, A_3G, and A_1A_3. The sum of the six similar expressions reduces without difficulty to (14).

The paucity of reference books on the geometry of the tetrahedron in English is especially noticeable. In a recent article[7] giving a rather extensive bibliography on the geometry of the tetrahedron, the only treatises in English mentioned were: J. L. Coolidge, *A treatise on the circle and the sphere*, Oxford, 1916, pp. 233–240; and George Salmon, *Geometry of three dimensions*, 5th edition, 2 vols. (1912 and 1915), London, Longmans, vol. 1, pp. 138–145. Numerous shorter articles are found in the periodical literature and attention is particularly directed to an article in the *Mathematics Teacher*, 1933, pp. 46–52; and the *American Mathematical Monthly*, 1932, pp. 193–199. A welcome addition to the literature of this field has been announced by Macmillan since this article went to press, namely: *Modern Pure Solid Geometry* by *N. A. Court*.

[7] Bennett, A. A., "The Lemoine Center in the geometry of the tetrahedron," *Am. Math. Monthly*, Jan. 1932, p. 18.

THE USE OF A STENCIL IN CHEMISTRY REPORTS

By Edward P. Heether
Williamsport, Pennsylvania

In these days of cutting costs we are attempting to teach more effectively and efficiently in order to avoid the specter of false economy. Many teachers of high school chemistry believe that the plan of teaching the pupil to make his own complete account of the work more nearly approaches actual working conditions than filling in blank spaces of a printed form.

The old laboratory loose-leaf notebook contained an unruled page having a picture in three dimensions of the apparatus and opposite this page a ruled sheet with the written explanation and data of the work. The chemistry notebook of today contains a ruled note paper with smaller spaces between the lines and no unruled paper. A diagram or outline drawing of the apparatus is made near the top of the page. The procedure and routine account of the work follow immediately under this drawing. A saving of one sheet of paper is made.

The pupil need no longer be encumbered with a ruler and compass to make his drawings. He now uses a celluloid stencil containing cut-outs of all the important pieces of apparatus. The drawings are definite, concise outlines that tell a complete story about the apparatus used during the experiment. There are no trial lines, no "hairy" lines and no erasures. Good drawings require a sharp pencil. The use of a stencil encourages such a pencil.

The student begins his written work with a neat clarified drawing before him and a vivid mental picture of his apparatus. The stencil, after being used, is slipped into an envelope pasted in the back of his book where it requires no space and can always be found. His drawing is neater than that made by ordinary drawing tools. This quality of neatness is carried over into his written work, stimulating accurate thinking and clearer explanations. A task that is well begun has greater assurance of being a success than one otherwise started.

The stencil does not smother initiative or artistic temperament. The more able child will add a deft line here and there to make his interpretation of the work serve its purpose. Continuance of this neater type of work will develop a feeling of satisfaction that carries over into other subjects and ultimately becomes a permanent part of the individual.

SCIENCE TEACHING IN THE COLLEGE

By Richard R. Marsh

Gunnison County High School, Gunnison, Colorado

Whether training for the high school teaching of chemistry and biology or for the cultural appreciation of the living world and its chemistry, the curriculum of the Liberal Arts College and the Teachers College has wandered far from a sensible and suitable subject matter. It seems as though each school, ignoring the purposes of chartering, were entering into competition with the vocational schools: the land-grant colleges, the polytechnic schools, and the state universities. For what are they now training? Professional chemistry and research in the field of biology. These are the objectives of the vocational schools, not the province of the teachers college and college of liberal arts.

Need we wonder why the average high school teacher of

biology must depend upon preserved specimens, dissection note-book drawing, and scientific vocabulary to constitute the bulk of his course, and the chemistry teacher in high school must teach a modified course made up of inorganic, organic and qualitative analysis chemistry? The problem is, where can he obtain training for teaching any kind of biology and chemistry other than that now given in the modern curriculum of these institutions of higher learning. Investigate the scheduled courses, especially for the first two years, and try to find any hint of interest to be found within them. How many freshmen taking a general course would "elect" to take the first course in either biology or chemistry if they were not required to take it?

What are some of the reasons for this situation? First: Tradition. The University customarily sets the example and requirements for the colleges within the state. Since the men and women on university staffs are primarily trained for independent research and are training others for that, and for technology in specific fields, they seldom have a broadened science training experience of their own. By the very nature of their work they cannot permit such digression from a chosen field. The sad part is that they so generally are unsympathetic with an unscientific attitude of wanting to study natural science for pleasure—not for life work, for understanding—not to make a contribution to world knowledge. So, they hesitate to "accredit" such courses in the liberal arts colleges. The second reason: Staff. Every department head must now be a university trained man and almost all colleges today are replacing master's degree with doctor's degree instructors—which degree, incidentally, is a certificate not for teaching but for ability in research—. These men, of course, teach their students in the light of their own training and interests. The students then are disillusioned and disappointed or, if they should happen to attempt to teach high school students, pass on to them the same materials and wonder why the graduate of college and high school is bored rather than fascinated with hobbies of nature study and amateur chemistry. Natural sciences are a nuisance rather than a pleasure to them. But how could they afford the expensive equipment of the colleges, even though they might wish to indulge?

Many of the modern high school science teachers are aware that chemistry and biology are not interesting the student as they should. Even if he should determine to spend several summers in study trying to improve his teaching materials and back-

ground, where could he go to find non-technical courses in chemistry and biology? Almost nowhere!

How can this maladjustment be corrected? In several ways. Perhaps the following suggestions in reorganization might be a start in the right direction. Let the first two years of biology be devoted to the following courses: Plant and Animal Nature Study, Ecology of the Field, Ecology of Pond and Stream, Bird-study (not ornithology, which is much too technical), Museum Methods and Technic, Natural Art, and so on. Let the introductory chemistry courses be: Chemistry of the Home, Chemistry in Industry, Chemistry in Drugs and Medicine, History of Chemistry and so forth.

Next, these courses should not be taught by technical men. Let us arbitrarily reorganize the teaching staff as well as the first two years of course work. Let the schools employ the doctor as head of the department for two reasons: because the North Central Association requires it and second, to train advanced students who wish to prepare for conducting research along these lines of activity. For the first two years, require that the courses be taught by men who are positively not trained for research but have spent several summers in the field and know living, natural biology; who have spent several summers in industrial plants, and so on, and can teach the tentatively indicated chemistry courses of an introductory and cultural nature.

Why can not we have interesting, living, usable science courses in terms of the high school teachers' needs and for the layman who may one day be earning a living in any field other than science? I believe we can and that the students, if they could once experience such a curriculum of science, would rebel at the situation present today and would demand the kind of science instruction they really want and need.

DOG, HERO OF RESEARCH, HONORED BY MONUMENT

In honor of the dog, so often the hero and invaluable aid of medical research, a bronze monument will be erected on the territory of the All-Union Institute of Experimental Medicine here.

The Monument to the Dog, as it is to be called, will be erected at the suggestion of Academician I. Pavlov whose famous discoveries in physiology were made by means of studies with dogs.

The monument is to be a bronze image of a sitting dog on a pedestal. Bas-reliefs on all four sides of the pedestal will depict separate moments from the life of the dog at Pavlov's laboratory.

ANNUAL MEETING EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Thirtieth Meeting

GROTON SCHOOL

Groton, Mass.

SATURDAY, MAY 18, 1935

PROGRAM

10:00 Meeting of the Executive Committee.
10:15 Business Meeting.
Annual Report of the Secretary.
Annual Report of the Treasurer.
Report of the Nominating Committee.
Election of Officers.
10:30 Report of Committee on New Apparatus and other Committees.
10:45 Address of Welcome: Mr. Clifford S. Griswold, Head of Science Department, Groton School.
10:55 Annual Address of the Vice-President, Mr. J. M. Arthur, St. Mark's School, Southboro, Mass. Subject: "Some Useful Home-made Apparatus."
11:30 Address: "Natural Color Photography." Illustrated by exhibits, slides, and the new color film Kodachrome. Mr. Arthur P. Murray, specialist in natural color photography.
1:30 Lunch at Parents' House. Price seventy-five cents.
2:30 Address: "Ballistics." Capt. Charles T. Van Ambergh, Ballistic expert of the Massachusetts Department of Public Safety.
3:15 Inspection of Science Laboratories.

The meeting will be held in "The Dome."

Times given on this program are Daylight Saving.

The Committee on College Entrance Requirements has an interesting report to bring to your attention from the Commission on Examinations in Science of the College Entrance Examination Board.

Trip to the Boston Airport, Saturday, May 25. See enclosed notice for details.

OFFICERS OF EASTERN ASSOCIATION OF PHYSICS TEACHERS

President, WILLIAM E. SMITH, English High School, Boston, Mass.
Vice-President, JOSEPH M. ARTHUR, St. Mark's School, Southboro, Mass.
Secretary, WILLIAM W. OBEAR, High School, Somerville, Mass.
Treasurer, PRESTON W. SMITH, Rivers School, Brookline, Mass.

TREASURER'S REPORT FOR 1934–35

Balance from previous year $327.73

		Sch. Science
Receipts: Dues 1933–'34 Act....	$ 2.00	$ 1.00

1933–'34 Assoc..	1.00	1.00		
1934–'35 Act....	99.00	196.00		
1934–'35 Assoc..	25.00	26.00		
1935–'36 Act....	1.00	2.00		
1935–'36 Assoc..	—	—		
	$128.00	$226.00	$354.00	
Interest			6.33	360.33
				$688.06
Expenditures:				
Printing & stationery		$31.50		
Postage & clerical expenses				
Secretary		22.30		
Treasurer		9.27		
Salary of Secretary		50.00		
Expense of meetings		—	$113.07	
School Science			$228.00	
				$341.07
Balance forward				$346.99
Assets				
Arlington National Bank (check'g acct.)			$202.72	
Charlestown Five Cents Savings Bank			142.92	
Cash			1.35	$346.99

Respectfully submitted,
PRESTON W. SMITH, *Treasurer*

ANNUAL REPORT OF THE SECRETARY

Our three regular meetings this year have been held December 8, 1934 at Boston University, March 9, 1935 at Massachusetts Institute of Technology, and May 18, 1935 at the Groton School.

The programs have been up to date and have provided much interesting material to stimulate our professional interest. We have cooperated in parts of meetings with the New England Association of Colleges and Secondary Schools and the Northeastern Section of the American Physical Society.

Our present membership totals 143, consisting of 112 active, 30 associate and 2 honorary. It is an encouraging sign that we are receiving applications from prospective members at every meeting. The early fall would seem to be the best time to get new members interested and the Secretary urges each member to help extend the influence of this organization by signing up new members before the November meeting.

The committee on Industrial trips has arranged two trips during the year. On March 23 a party of about 30 visited the Edison Plant at Weymouth and were very courteously given every opportunity to inspect the plant from top to bottom. We also visited the transmitting station of W.E.E.I. which, though small in extent, proved to be exceedingly interesting.

The other trip is to be to the East Boston Airport Saturday, May 25. It offers many features of interest.

Respectfully submitted,
WILLIAM W. OBEAR, *Secretary*

It was voted to accept the reports of the Treasurer and Secretary.

The nominating committee, Mr. Louis Wendelstein, Mr. William Rice and Mr. James Dyson, presented the following candidates and they were elected to serve for the ensuing year.

President: Lawrence A. Howard, East Boston High School.
Vice-President: Robert W. Perry, Malden High School.
Secretary: William W. Obear, Somerville High School .
Treasurer: Preston W. Smith, Rivers School, Brookline.
Executive Committee: John P. Brennan, Somerville High School, Ralph H. Houser, Roxbury Latin School, and Thomas A. Pickett, Mechanic Arts High School, Boston.

The following were elected to active membership,
Michael B. Gillespie, High School, Scituate, Mass.
Regina Maria Hughes, Abbot Academy, Andover, Mass.

Mr. Hollis Hatch showed three brass circles with diameters of 12.1,12.1, and 24.2 cm. When you are discussing the areas of circles as in the hydraulic press or the resistance of wires it is necessary that the student see that doubling the diameter more than doubles the area. If you place the two small circles against the large one it is evident that a lot of area is left over. The particular figures given above are chosen because (1) the size is large enough so that they can be seen at the back of the room and (2) the areas calculated from these diameters come out 115.0 and 460.0, numbers which it is easy to see are in the ratio of one to four.

Upon motion of Mr. Miller it was voted to extend the thanks of the Association to Dr. Peabody, Mr. Griswold, and Mrs. Carter of Parents' House for their hospitality in entertaining us at the Groton School today.

REPORT OF COMMITTEE ON MAGAZINE LITERATURE AND NEW BOOKS

MR. C. W. STAPLES, *Chelsea High School, Chairman*

NEW BOOKS

New Pathways of Science, by Sir Arthur Eddington. Macmillan Co., Publishers. $3.00.

The Book of Electrical Wonders, by Ellison Hawks, F.R.A.S. The Dial Press, Publishers, $1.69. A book about the history of modern electrical inventions and the discovery of various electrical principles, written for students and beginners in the subject.

The New World of Science, by A. Frederick Collins, F.A.R.S. A book containing descriptions of recent inventions and development of the sciences, written simply, for students. J. B. Lippincott Co., Philadelphia, Publishers. $2.50.

MAGAZINE LITERATURE

Astrophysics

"Spectroscopic Absolute Magnitudes and Parallaxes of 4179 Stars," *Astrophysical Journal*, April, 1935. P. 187.

"New Eyes on the Universe," by G. W. Gray, *Atlantic Monthly*, May, 1935. P. 607–16.

"Historic Telescope Clocks the Pleiades," *Literary Digest*, April 6, 1935. P. 17.

Atmosphere

"Le Profil reel des Nuages Revele par la Photographie a Longue Distance," *L'Illustration*, March 23, 1935. P. 338.

"Five Unusual Theatre Air-Conditioning Installations," *Heating and Ventilating*, April, 1935.

"Laboratories in the Stratosphere, National Geographic Society—American Army Air-Corp Stratosphere Expedition," by L. J. Briner, *Sci. Monthly*, April, 1935. P. 295–306.

Atomic Physics

"New Determination for the Atomic Weight of Hydrogen," by W. Davis *Science*, 81 (sup. P. 6) March 22, 1935.

"Stable and Unstable Nuclei," by R. W. Ladenburg, *Science*, April, 1935. P. 307–12.

Aviation

"Does Latest Disaster Spell the Doom of the Dirigible?" *Popular Science Monthly*, May, 1935. P. 26.

"Fly High for Comfort," by R. M. Cleveland, *Scientific American*, April, 1935. P. 196–7.

"Autogyros, Diesels, and Secret Rays; New Aircraft Developments Including Vertical Take-Off," *Literary Digest*, March 17, 1935.

"Study of Airplane Propellers," *Science*, (Sup. P. 8.) March 15, 1935.

"Full-Size Planes Tested in Big Air Tunnel; High Speed Camera See Fuel Combustion" (Drawings), *Popular Mechanics*, April, 1935. P. 520.

"German Automatic Pilot," by A. Klemin (diagrams), *Scientific American*, May, 1935. P. 242.

Electricity

"Ion Distribution During Initial Stages of Spark Discharge in Non-Uniform Fields," by Charles D. Bradley and L. B. Snoddy, *Physical Review*, April 1, 1935. P. 533.

"Juggling Thunderbolts with Huge Home-Made Spark-Coil," by Kendale Ford, *Popular Science Monthly*, May, 1935. P. 82.

"More Powerful Electric Locomotives," *Scientific American*, April, 1935. P. 212.

"Giant Electromagnets to Measure Cosmic Rays at University of Chicago," *Literary Digest*, March 30, 1935. P. 16.

Fluorescence

"Blue Light in the Sea: Undersea Illumination and Fluorescence of the Eye," by E. O. Hulburt, *Science*, (81) March 22, 1935. P. 293–4.

Freedom of Thought and Speech

"Free Inquiry or Dogma?" by James Bryant Conant, *Atlantic Monthly* April, 1935. P. 436.

Geophysics.

"Le Musee Vulcanologique de Saint Pierre de Martinique," *L'Illustration*, March 23, 1935. P. 342.

"Tiny Machine Shakes Huge Buildings in Novel Earthquake Tests," *Popular Science Monthly*, May, 1935, P. 16.

"Magnetic Prospecting on the Rand." *Engineering and Mining Journal*, March, 1935, P. 121.

Heat

"Sleepwalking Locomotives Provide a Real Railroad Mystery," *Popular Science*, April, 1935. P. 37.

Historical Physics

"A Visit to Piccard," by G. Prokofiev, *The Living Age*, April, 1935. P. 132.
"The Whale-Oil Burner; Its Invention and Development," by C. Malcolm Watkins, *Antiques*, April, 1935. P. 148.
"Modern Engineering Feats Eclipse Wonders of the Past," *Popular Science*, April, 1935. P. 11.

Hydraulics

"New Undersea Escape Device Is Complete Baby Submarine," *Popular Science Monthly*, June, 1935. P. 37.

Invisible Radiations

"Secondary and Tertiary Particles Produced by Cosmic Rays," by I. H. Sawyer, Jr., *Physical Review*, April 1, 1935. P. 515.
"X-Ray Machine Now Shows Three Dimensions," *Popular Science Monthly*, June, 1935. P. 28.

Light

"The Constancy of the Velocity of Light," by Roy I. Kennedy, *Physical Review*, April 1, 1935. P. 533.
"The Manufacture of Neon and Other Rare Gas Tubes," by Paul Möbius, *Engineering Progress*, March, 1935. P. 77.
"Sodium Lamps at Pompton Lakes, N. J. Forecast Highway Safety," *American City*, March, 1935. P. 101.
"Scattering of Light in Dust Storms," *Science*, (81) sup. P. 8. April 5, 1935

Materials

"Sulphur Mined by Blasting in World's Biggest Deposit" (California), *Popular Science Monthly*, June, 1935. P. 22.

Meteorology

"A Shelter for Your Weather Instruments" (Diagrams, plans, etc.), *Popular Science Monthly*, May, 1935. P. 63.
"Investigation of Weather Conditions in the Stratosphere by Means of Sounding Balloons," *Science*, April 12, 1935. P. 356.
"Instruments Indicate Temperature and Humidity," *Science*, March 15, 1935. (Sup. P. 9.)

Photography

"Pictures in Full Color," *Popular Science Monthly*, May, 1935. P. 13.
"Making 3-Dimensional Pictures With Your Microscope," *Popular Science Monthly*, May, 1935. P. 42.
"Cleaning a Camera Lens," *Popular Science Monthly*, May, 1935. P. 68.
"How to do Modern Stereoscopic Photography," *Popular Science Monthly*, April, 1935. P. 70.
"Photography in Two Selected Wave-Lengths," *Scientific American*, April, 1935. P. 174.
"Construction of a Miniature Enlarger" (Diagrams), by M. F. Mohle, *American Photography*, April, 1935. P. 255–7.
"Pinhole Photography," by F. W. Breham, *Scientific American*, April, 1935. P. 191.

"Candid Photography; Amateur Photography with Miniature Cameras with High Speed Lenses," by J. Deschim, *Scientific American*, May, 1935. P. 250–251.

"Photography in Crime Detection. Quick, Watson, the Camera," by H. M. Robinson, *Forum*, May, 1935. P. 290–3.

Radio

"Ionosphere," by W. M. Goodall, *Bell Laboratories Record*, March, 1935. P. 194.

"Insulation Resistance of Cotton," by A. C. Walker, *Bell Laboratories Record*, March, 1935. P. 209.

"A 50-K.W. Transmitter of High Fidelity," by J. C. Herber. *Bell Laboratories Record*, April, 1935. P. 227.

"Controlled Radiation for Broadcastings," by J. F. Morrison. *Bell Laboratories Record*, April, 1935. P. 232.

"Runaway Radio Waves," *Popular Science Monthly*, June, 1935. P. 11.

"Portable 5-Meter Transceiver" (Diagrams), *Popular Mechanics*, April, 1935. P. 581.

"Transmission of Ultra-Short Radio Waves," *Science*, (81) Sup. P. 6–7, March 22, 1935.

"Kruesi Radio Compass," by A. Klemin (diagrams), *Scientific American*, May, 1935. P. 240–1.

"Fifteen Pound Aircraft Radio Transmitter," *Scientific American*, May, 1935. P. 268.

Sound

"Demonstration of Beat Note and Other Acoustic Phenomena," by R.M. Sutton. (Diagrams) *Science*, (81) March 8, 1935. P. 255.

Television

"Television," by Ambrose Fleming, *Nineteenth Century and After*, March 1935. P. 351.

Prof. Black recommended "A Source Book in Physics" by William F. Magie of Princeton, published by McGraw-Hill Book Company.

REPORT OF COMMITTEE ON CURRENT EVENTS

J. P. BRENNAN, *Somerville High School, Chairman*

Researches at the Forest Products Laboratories are showing that smaller floor joists, spaced farther apart, will safely carry usual floor loads when the joists are covered top and bottom with well bonded plywood. Finish floors may be laid over the upper plywood and the lower plywood surface may be finished to serve as a ceiling. A floor section of this type, but with the addition of an inserted plywood arch, was exhibited at the recent open house day program at the Massachusetts Institute of Technology.

The new 50,000 Kilowatt transmitter located at Carteret, New, Jersey, for station WOR has been recently opened and represents the last word in modern broadcasting transmitting station. Carteret was chosen as the location because of its proximity to the dense population of New York and Philadelphia and because of the great areas of swampy ground in that vicinity. Swampy ground makes an admirable "ground" for a transmitting station. Forty miles of copper wire are laid underground in this swampy area, a long cable runs along a creek bed which empties into the sea and in

the building itself about 14,000 welds have unified the metal parts of the shell and the structural steel units into one great shield to improve the efficiency of the transmitter. It is expected that the heat given off by the $8,500 worth of radio tubes in operation when the station is on schedule will be sufficient to maintain a temperature of 70°F. within the building when the thermometer outside registers as low as 10°F. The heat from the tubes is to be distributed by a water cooling system which at the same time is to be the hot water heating system for the building.

A piano made entirely of steel is being manufactured jointly by several American Manufacturing Companies. The wires and sounding board are being made at Worcester, Mass. by the American Steel and Wire Co., some mechanical parts are being made by the L. C. Smith and Corona Typewriters, Inc., and it is to be placed on the market by the Steinway Co. It is said that the all steel piano will weigh less than the present day type and that the quality of the sound will be improved.

Using an adaptation of the anaglyph picture, Louis Lumiere, the celebrated French inventor of photographic processes, has devised a scheme for showing moving pictures in stereoscopic relief. He has divided the spectrum into halves at the line of greatest intensity. Two pictures of the scene are taken one with the light to the left of the dividing line, and the other with the light to the right of the line. The two pictures are thrown on the same screen simultaneously and viewed through differently colored glasses set in a spectacle frame. The rays passing through each lens of the spectacles are complimentary to each other so that the combination gives a black and white image.

A step forward in color photography for amateurs has been made with the development of a film on which are printed in crisscross fashion colored lines of red, blue and green. These lines act as a color filter and produce colored pictures that may be projected on the screen.

When Professor Klaus Hanson of Oslo, Norway, drank some of the heavy water that has proved fatal to certain low forms of animal life, he is reported to have said, "It has a dry, burning sensation." Wishing to repeat the experiment Dr. Vrey discoverer of hydrogen isotope, from which the heavy water is made, had an assistant prepare two unlabelled drinking glasses, one of which contained about twenty drops of the heavy water and the other about the same quantity of ordinary distilled water. Having drunk contents of each glass Dr. Vrey is reported to have said that he could not distinguish one liquid from the other.

Mr. Griswold bade us a hearty welcome to the Groton School. He referred to a meeting of the Association here 25 years ago at which Prof. Wallace Sabine was the speaker. He expressed his satisfaction in having followed Science teaching as his field notwithstanding the amount of work required in keeping up with so rapidly a developing subject. He ventured the opinion that the classics would be much better understood if all had a science background.

The address of the vice-president, Mr. Arthur, of St. Mark's School consisted of explanation and demonstration of apparatus.

First, a device to measure "g" by free fall of a metal ball, using the 110-volt, 60-cycle current as a timer. Freedom from any magnetic circuits makes the construction of the apparatus quite easy. A description of the mechanism and circuits was printed in SCHOOL SCIENCE AND MATHEMATICS for May, 1933 and will not be repeated here.

Then an optical disc was shown, equipped with a revolving light source which was counterpoised and so attached to the light shield that the light beams could be directed instantly along any diameter of the disc. The ar-

rangement is particularly convenient in showing equality of angles of incidence and reflection with a mirror, for showing the critical angle for glass, and for any work with a refraction tank.

For direct determination of the velocity of sound in the open air there was a pair of "clappers," made of oak, about $12 \times 4 \times \frac{3}{4}$ in., hinged at one end and provided with handles. A musician's metronome was used as a timing guide. With the metronome beating $\frac{3}{4}$ sec. intervals, one student times his strokes of the clappers to synchronize with the clicks of the timer as the observers move away from him. When the strokes of the clappers seem once again to coincide with the sound the observers are, of course, at a distance equal to the velocity of sound for the $\frac{3}{4}$ sec. interval.

An unannounced feature of the program which proved to be extremely interesting was an informal talk on "Cathedral Bells and Bell Ringing" by Mr. S. W. Sturgis of the Groton School. Then with the help of three of the Groton boys a short "touch" on eight bells was rung. England is the center and home of the most scientific bell ringing. Several thousand sets of bells, numbering from eight to twelve, are regularly rung at least once a week for Sunday services. If the bells are rung in regular succession from the "Treble" or highest toned bell to the "Tenor" or deepest toned bell it is known as "rounds." But mere rounds, or the repetition of a few stereotyped variations in the order of the bells soon becomes wearisome, and so has led to "scientific change ringing" a system by which, starting with rounds, a new order of the bells is produced at each pull of the ropes, until without any repetition of the same change the bells come back into rounds. On eight bells 40,320 different changes may be produced. To ring this number would require about 25 hours of continuous ringing. Any number of changes over 5000 is known as a "peal" and this, requiring a little over three hours, is the standard length of scientific ringing. The invention and application of methods to regulate the work of each bell so as to produce the definite number of changes required offers a fascinating opportunity for almost unlimited mathematical ingenuity, as well as exercise of musical taste.

NATURAL COLOR PHOTOGRAPHY

By Arthur P. Murray

Read by William H. Doherty

The earliest available records of the human race contain evidence of attempts to portray or reproduce the beautiful colors of nature. Recent excavations by the French Academy have uncovered in caves crude carvings estimated to be 15 to 25,000 years old. These carvings were colored with oxide of iron. Beautiful marble statues carved by the Greeks many years ago still show traces of color and are to be found in the Acropolis. From the time of the earliest paintings, painters have striven to reproduce the colors in the world around them. Thus we see that the struggle to reproduce nature in her colors and splendor has been going on for thousands of years.

The discovery of the sensitivity of silver halides marked the arrival of a method of reproducing nature more accurately than hitherto. It was the starting point of the photographic era. This method however, was limited to monochrome reproduction and while it has been one of the most beneficial discoveries to mankind, it still lacks the beauty of the colors of nature.

Through subsequent modifications, improvements and adaptions, photography, both still and motion has added to the education, science, practical progress and entertainment of the race to an inestimable degree. That color would enhance reproductions was, as we have pointed out, realized early in the history of man, but it was not until about 75 years ago that any definite progress was made in the attempt to reproduce the colors of nature by means of photography.

Before outlining the progress of color photography during the past 75 years, it will be well for us to touch on the theory of light. Although, without doubt, the present audience understands well the nature of light, so much of colored photography depends on a few fundamental principles that your indulgence is asked while the fundamentals are briefly outlined.

For the purpose of this paper, we will assume that light consists of waves in the ether, and that this ether is spread through all space. If we analyze white light with a spectroscope, we see that it is spread into a band of different colors that merge into one another without any breaks. As you know, this is called the spectrum.

Upon further examination we find that this spectrum consists of waves of different length, the smallest being the violet and the longest the red. Measurements made of these waves are defined in terms of Angstrom units, which are ten-millionths of a millimeter. It is also customary to classify them in millimicrons, which are millionths of a millimeter. We shall follow the latter classification. The visible spectrum extends from about 400 millimicrons to about 700. The visible spectrum, with which we are primarily concerned may be divided into three equal parts. We may refer broadly to these parts as being blue (400 to 500), green (500 to 600) and red (600 to 700). If we place a reversed spectroscope in such a manner that the spectrum produced by the first one is reconverted back into white light, and insert a piece of colored glass into the setup, we notice that we have lost a certain portion of our spectrum. This lost portion has been absorbed by the glass, and is known as the absorption band of that particular glass. The portion of the spectrum that is transmitted, its transmission band, is known as the color of the glass, which, in this case, is red. It is evident, therefore, that the wavelengths that are absorbed determine the color of an object. This is very important for a thorough understanding of the principles of color photography. If we define a color by the portions of light which it absorbs, then our definition holds without reference to the color of the incident light. For this reason an object is yellow because it absorbs blue and reflects green and red light which constitute yellow; an object is red because it absorbs blue and green, and an object is green because it absorbs the blue and red. The colors absorbed by an object are complementary to the colors that it reflects or transmits and complimentary colors play an important part in color photography.

The possibility of reproducing objects in natural colors by photography was first suggested by Clerk Maxwell in 1861. Sir Isaac Newton had previously discovered the solar spectrum and divided it into seven colors:—

Violet—Indigo—Blue—Green—Yellow—Orange—Red. C. E. Wunch (Vunch) in 1792 published in Germany, a theory that white light could be divided up into 3 colors, red, green and blue-violet, and that all visible colors could be made by mixing these three primary colors in various proportions.

In 1807 Thomas Young propounded a theory, known as the Young-Helmholtz theory. Young claimed that the human eye had three distinct modes of sensation in the retina. One group of nerves sensitive to red, another to green, and another to blue. The sensation of these varied according to the amount of radiation they received and while the red sensation nerves were affected chiefly by the red rays, they were also sensitive to some degree to the other waves of the spectrum.

Clerk Maxwell, evidently having this theory in mind, reasoned that if the eye could separate and reunite the colors that possibly the camera could. He proceeded to carry out his experiment using ammoniacal copper sulphate to isolate the blue, copper chloride for the green and iron sulphocyanide for the red. For some reason Maxwell added a fourth filter to this experiment and used a piece of lemon yellow glass for the yellow.

The negatives were obtained after prolonged exposure, developed, and positives made. The positives were placed in magic lanterns each positive having in front of its lantern, the corresponding filter. When the images from these four lanterns were superimposed on the screen and the intensities of the several lights adjusted, a color picture was visible on the screen. While far from perfect, this picture was the first natural color photograph ever to be made. This experiment of Maxwell's established the principles of additive color photography, namely, the separation of the constituent colors on to separate negative records and the reassembling of the positives by projection into a composite picture using the same filters for taking and viewing.

In 1868 Ducos du Hauron outlined a theory that the colors to be used in printing colored pictures should be antichromatic to the taking filters, namely red, yellow and green. This theory, supported a year later by Charles Cros, another pioneer in colored photography, laid down the basis of color photography by the subtractive process.

Since it is customary to classify all colored processes into additive or subtractive methods, it is well to explain their difference at this time. In additive methods we may consider ourselves as starting with a dark screen and add from different lanterns different components of white light until we build up the color that we desire. In the subtractive method, we can consider our having a screen of white light and subtracting or absorbing colors until the resulting color is the one desired.

The next important step in the history of color photography occurred in 1873.

It must be remembered that while the photographic plate is actually sensitive to all the spectrum waves, and therefore to all colors, it was so

sensitive to the ultra violet, violet and blue that under ordinary conditions the plate did not record much of other colors.

H. W. Vogel while using a plate with a yellow dye incorporated in the emulsion to minimize halations, discovered that the plate was more sensitive to the green of the solar spectrum than undyed plates. To ascertain this definitely, Vogel washed the dye out of an unexposed plate and found the green was not recorded when exposed under the same conditions. Vogel then tried other dyes and as a result of his work, dyes were found that would sensitize for the green. Such plates are called orthochromatic (Kodak Verichrome being of this type).

Further research brought to light dyes of the aniline type that sensitized the plate for the red region. This was therefore the starting point of panchromatic plates.

The last big obstacle to color photography had now been removed and many and different methods of making colored photographs appeared everywhere.

Of these many methods we will only mention those that have had some commercial success and only explain those that are still on the market today.

Pursuant to our classification, we will outline first, the additive methods.

ADDITIVE PROCESSES

Ducos du Hauran, whom we have mentioned before, conceived the idea of covering a translucent sheet with three colored grains. These colored grains would act as so many small cameras in the taking of the picture and as so many lanterns in the projecting of the picture.

This was the starting point of Screen plate processes. The first commercially successful plate of this type was the Autochrome invented by the Lumiere brothers in France. Starch grains were sifted by means of an extremely fine sieve. The grains were then dyed and spread on to a glass plate over which the emulsion was spread. After exposure and development the developed silver is bleached and washed and the unexposed silver bromide is then developed in the presence of white light. This produces a positive and incidently is the method used in developing amateur 16 mm. movies.

The Agfa color plate is similar to the Lumiere with the exception that the pattern is produced by tiny droplets of dyes in colloidal suspension in unmixable liquids. After the droplets have dried the screen is varnished and an emulsion coated thereon. Of course in screen plates the exposure is made through the screen.

Another color plate much used at the present time is the Finlay Color plate. This plate invented by C. Finlay was originally known as the Paget Plate. In its present form the Finlay screen is separate and distinct from the emulsion.

The 175 line screen plate is placed in contact with a specially prepared high speed Eastman panchromatic plate, and exposed in the ordinary

camera. Registering marks on the screen allow the plate to be re-registered after development. The advantages of this type plate are:

First—By registering a viewing screen with a positive made from the negative a natural color transparency results.

Second—By registering the negative with special block out screens, positives may be made which represent the red record only, and by repeating the process with other block out screens three positives may be obtained which are known as separation positives. These can then be used to produce a picture by the subtractive method.

The Dufay plate originally introduced as the Diopticolor and later as the Dioptichrome has undergone many transformations since its beginning. At the present time the process is owned by the Spicer Dufay Co. Ltd. and their plant is at Sawston, England. Dufays bid for fame at the present time is the fact that the screen is put on moving picture film. Very fine lines engraved on a steel drum are inked and an impression made on blue dyed film. The blue dye is bleached where the ink does not protect it and is then dyed red. The ink is then removed and the film receives an impression from inked rollers that are engraved at right angles to the first lines. The red and blue dye is then bleached where the ink does not protect it and is dyed green. After the ink is removed a silver bromide emulsion is coated on the film. Because the film is of the so called safety base type, Dufay had been making good process in the 16 mm. field but the advent of Eastmans new Kodachrome process will probably curtail its popularity.

R. Berthon in 1909 patented the use of a lens covered with red, green and blue violet filters and a film the support of which contained hemispherical protuberances which acted like spherical lenses. Anthon Kellerorian patented a method of forming the lenticules on celluloid by means of an engraved plate or cylinder. They also marketed this film as 35 mm. or standard size film. However little was heard of this process until it was introduced by the Eastman Kodak Company in July 1929 as the Kodacolor process.

SUBTRACTIVE PROCESSES

As with the additive processes, we will now mention the chief subtractive processes that are in use at the present time.

The Carbo process marketed by the Autotype Co., Ltd., is an improvement of the Ozotype process patented in 1898 by an Englishman name Manly. In its present form the Autotype Co. manufactures 3 colored carbon tissues. These consist of separate sheets coated with gelatin in which is incorporated a colored pigment, a yellow in one, magenta in another and blue green in the third. In practice one makes 3 enlargements or prints on bromide paper in this usual way, one from each of the 3 separation negatives, which we will assume have been made. The carbon tissues are then soaked in a weak bichromate solution and each one squeezed into contact with its proper bromide print. During the five minutes in which they are in contact, the chemical reaction between the silver of the print and the bichromate in the tissue hardens the gelatin where the silver was

located. This hardened insoluble gelatin remains on the celluloid when it is immersed in hot water, while the unhardened gelatin washes off. These three colored tissues may then be superimposed to form a transparency. If a colored print is desired the pigment layer may be stripped from the support and transferred to paper and the other 2 colored layers transferred on to the same piece of paper in a superimposed position.

Because of the unusual technique required, this process is rather limited but some of the best natural color prints that have been seen have been made by this method.

Toning processes also of the subtractive class have been in evidence in the last few years. These include chemically toning and dye toning. Insofar as Multicolor seen on the screen a few years ago, is a combination of both processes, an explanation of that process will cover both classes. Without going into the historical development of toning, it should be mentioned that Testual de Beauregard as early as 1855 obtained colored pictures by this method.

The Multicolor process is a two color process. We have been speaking of three color process until now, and while the two color processes will not give the range of colors or beauty that the three color will, nevertheless in view of the fact that both Multicolor and Technicolor have been such processes it will be well for us to explain its origin.

As in most of the historical references given heretofor, we must refer to Ducos du Hauron for the origin of this method. Du Hauron discovered that by eliminating the yellow printer he could approximate the colors in photographs quite satisfactorily, if they were viewed by artificial light, which as we all know contains more yellow than daylight. At about the same time, while experimenting with the separating of the colors into two negatives instead of three, du Hauron suggested the use of a bipack. At that time the graininess of the silver bromide emulsions were such that good results could not be achieved. However, at the present time, the Dupont Film Co. manufacture a bipack known as Dupack, that was used by Multicolor for their negative records. The Dupak consists of two films placed in contact with each other, emulsion to emulsion, and used in the ordinary camera. The exposure is made through the support of the front element which is the green record and the image continues through the quite transparent emulsion to the rear one; the red record.

These 2 negative records, since they were taken at the same time in the same camera, are geometrically identical. They are then placed in a duplex printer and positives printed on each side of a double coated film. After this positive film is developed, the silver image is toned. One side of the film is bleached and chemically converted to Prussian blue. This is known as chemical toning. The other side would have the image chemically changed to a Uranium compound and then placed in a red dye which would be mordanted by the uranium wherever the image was. This is known as dye toning.

There is still another type of subtractive process known as Relief proc-

ess and may be attributed to C. Cros whom we have mentioned before. These reliefs may be made in many different ways. However, the three most generally employed are:

1—By the action of light on bichromate
2—By the use of a hardening bleach
3—By the use of a hardening developer

In the bichromate method, gelatin is sensitized in a bichromate solution and allowed to dry in a dark room. When an image is printed photographically on to this bichromated film by ultra violet light the gelatin is rendered insoluble wherever the image was formed. Subsequent washing in hot water, or etching as we will refer to it, washed away the insoluble gelatin leaving a gelatin relief image.

By printing an image on to a silver bromide gelatin emulsion and developing in a non hardening developer, we can cause the silver to harden the gelatin locally by bleaching in chromic acid. Etching then produces a gelatin relief. The third method is similar to the second but a developer is employed that hardens the gelatin locally as it develops. The silver is then removed by a non hardening bleach and after etching a gelatin relief results. The reliefs are immersed each in a separate colored dye and when dry are placed in contact with each other in register and viewed in light.

Our next process in the subtractive class is Imbibition, of which Technicolor Film is perhaps the best known example. Technicolor owes its name to three Tech men, Dr. H. T. Kalmus, Dr. D. F. Comstock and Mr. W. B. Westcott who as research engineers developed the process.

Until 1934, Technicolor produced only (2-color) pictures; since that time (3-color) pictures are being made. With the exception of the camera and negative records and dyes, the two processes are sufficiently alike to treat as one process. In the three color process each stage assumes one more step similar to the 2 color of the older process.

The first step, of course is procuring the negative. The (two-color) negative that is used in the two color process is obtained by means of a special camera in which is incorporated a light splitting medium patented by Comstock.

In view of the fact that the physical problems encountered in the processing of Technicolor Film has been worked out by them and many of them patented and many of them not, some of the problems encountered will be enumerated but no attempt will be made to explain their solution.

The negative is placed in a projection printer, and an image, the same size as the negative image is formed on the positive. During operation the negative film moves two frames for every one frame of the positive. In this way all of the red record images are printed on the positive in a continuous sequence.

After all of one record has been printed the negative is turned upside down and run through the printer again forming the other record sequence.

Projection printers are nothing more or less than enlargers with the

foci so arranged that the ratio is 1 to 1. However it must be borne in mind that the films travel along at a good rate of speed. Precision in the lens, its focus and the placement of the negative and positive during the printing operation, is required. The red image formed on the positive must match exactly the corresponding green image so that later when they are superimposed and enlarged about 250 times on the screen there will be no difference in them. This gives us an idea of the precision required in the little pins that fit the perforations in the films and hold them in place during the operation. Should the red record be separated from the green record for any length of time the difference in atmospheric conditions could be sufficient to spoil the subsequent registering.

While the following is not the method employed by Technicolor, it is sufficiently similar to explain in detail the making of a matrix. Having printed our negative image on to the yellow dyed film through the base, let us develop it in an ordinary developer. After developing and washing the film we have a silver image situated close to the base of the film. If we bleach this image in chromic acid the chemical reaction taking place between the silver and the bleach will harden or tan the gelatin in the immediate vicinity of the silver. If we now place the film in hot water the chromic compound washes out together with the soft gelatin that was not in the vicinity of the image. The result upon drying is a gelatin layer varying in thickness according to the depth of the penetration of the printing light. Since the printing light varies inversely as the density of the negative, our relief is the opposite of the negative, namely a positive. If we would stain this matrix with a black neutral dye we would see that we have a true positive reproduction composed entirely of dye the amount varying as the thickness of the relief.

There is bound to be a loss of sharpness or definition in the back element of the bipack. This back element is the red record and its complimentary color or printing color is blue green. Blue green adds quite a bit to the print and consequently improves the quality of the finished print. Within the last year or so much progress has been made in bipaks that it is practically impossible to tell the red record from the green.

The matrices are now ready for transferring. A blank film, that is, one with a coating of gelatin, but without any silver bromide is soaked in water to swell it. The blank film is placed with the emulsion side down on top of the matrix which has previously been dyed and rinsed off. The two films are held in contact by a metal belt that has pins protruding from it into which the perforation of the film fit. The belt and the two films travel along and while so moving the dye transfers from the matrix to the blank film. After the transfer is completed, which takes about 5 minutes, the matrix is separated from the blank, is dried and rolled up ready for another run. The blank is dried, rolled up, rewound and placed back in the presoak bath. Then the second matrix is run through a different dye and is transferred on top of the previous image. In this manner 2 or 3 color prints or transfers are made. After the final color has been transferred the film is ready for projection.

The particular machines used in the transferring of the dyes from the matrix to the blank film are the result of years of theoretical planning and practical experimentation. Since the dyes are acid, corrosion problems are a big factor. The films must register to within thousandths of an inch during the transfer and the finished 3 color film after having three different dyes transferred into it must be as clear, sharp and well defined as black and white. Not only this but the dyes must balance with each other at all times. Specks of dirt between blank and matrix prevent transfer of dye, too high a relief takes too long to dry, too hard a relief takes too long to transfer. All these factors and many more are pretty much controlled by gauges and dials on the transfer machines.

At the conclusion of this address several Kodachrome films were projected.

Captain Charles T. Van Ambergh, Ballistic expert of the Massachusetts Department of Public Safety, gave an interesting talk on "Ballistics."He explained how evidence is obtained from firearms and bullets and, with references to well known cases, he showed how absolutely conclusive such evidence can be. There were many lantern slide illustrations of the various points.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTION

1385. *Norman S. Greiner, Somerville, N. Y. A. R. Haynes, Tacoma, Wash.*

Note on Problem 1379

In the solution to problem 1379 the Editor confesses to permitting an error of a serious nature. When N was found and substitution was made in (1), the word "log" was omitted. Also the log (log 9!) = .74505. When these corrections are made, log $M = 10^{2017500 .74505}$ and M consists of a number of $10^{2017500 .74505}$ plus 1 digits in its integral part.

The author of the solution called my attention to this blunder.

EDITOR

Note on Problem 1373

W. R. Smith, Chicago, and A. R. Haynes, Tacoma, Wash., have offered solutions which are not "satisfactory."

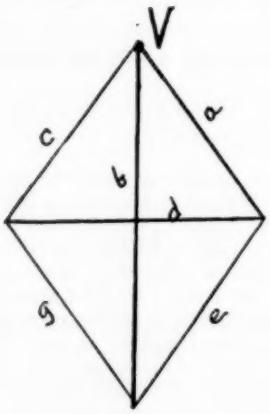
Mr. Haynes offers an attack on the problem by using analytic geometry. By use of general coordinates of the vertices and also numerical coordinates the solution "becomes almost hopelessly complex and involved."

EDITOR

SOLUTION OF PROBLEMS

1388. *Proposed by Dewey C. Duncan, University of California.*

A spider from the vertex of a regular tetrahedron sets out to traverse in the shortest possible way the six edges at least once each and return to the starting point. If each edge is 1 foot long how far does it travel? How many different courses could it pursue in performing the journey if courses performed in opposite directions are regarded as different.



Solution offered by W. R. Smith, Chicago

In order to travel each edge once he must travel two edges twice, hence, the distance covered is eight feet, and the total number of courses possible is 132.

Note by the Editor: Only a portion of the solution will be offered, just enough to indicate the way in which the problem was attacked.

If he leaves the vertex V via edge, a, on arriving at the base there are three possible paths which he may follow from that point: to retrace, a, to follow e, and to follow d. Since the figure is symmetrical, if he leaves the vertex via b there will be a possible course corresponding to each course

leaving over a and the total number of courses leaving over b will equal the total number leaving over a. The same will be true of the courses leaving the vertex via c.

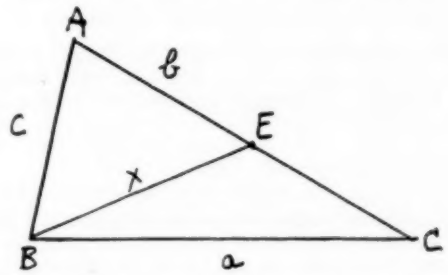
First find the number of courses leaving over a, and then determine how many of those leaving over b are reversals of those leaving over a and therefore duplications. In like manner make a similar test for the courses starting over c.

If he leaves over a and immediately retraces a there are six courses: *aabedggc, aabgdegc, aabggedc, aacdeggb, aacgedgb, aacggdeb*. Hence, counting reversals there are 12 courses starting *aa*.

By proceeding in a similar manner and checking out duplications 132 courses are found.

1389. *Proposed by Charles W. Trigg, Cumnock College, Los Angeles.*

In the triangle ABC, E is a point on AC such that $AE=AB$. Find the length of BE in terms of the sides, a, b, c, of the triangle.



Solution by Hyman Zalash, New York City.

(1) From triangle ABC, $a^2=b^2+c^2-2bc\cos A$, and $\cos A=\dfrac{b^2+c^2-a^2}{2bc}$.

(2) From triangle ABE, $x^2=2c^2-2c^2\cos A$.

Substituting from (1) in (2)

(3) $x^2=\dfrac{c}{b}(2bc-b^2-c^2+a^2)$. Hence

$$x=\sqrt{\frac{c}{b}[a^2-(b-c)^2]}, \text{ and if } 2s=a+b+c,$$

$$x=\frac{2}{b}\sqrt{bc(s-b)(s-c)}$$

Solutions were also offered by Isadore Chertoff, Bayone, N. J.; A. R. Haynes, Tacoma, Wash.; H. Leo Juditz, College of City of New York; Richard A. Miller, University of Mississippi; W. E. Buker, Leetsdale, Pa.; B. Felix John, Ida M. Fisher, Miami Beach, Florida; and the proposer.

1390. *Proposed by Maxwell Reade, Brooklyn.*

If $\dfrac{a-b}{a-q}=\dfrac{b-p}{q-b}$, prove that $\dfrac{1}{(a-p)(a-q)}-\dfrac{1}{(b-p)(q-b)}=\dfrac{-4}{(a-b)^2}$.

Note. Numerical substitution shows this to be an impossible problem.

EDITOR

1391. *Proposed by Hugh L. Demmer, Custer, South Dakota.*

Find an approximate solution to the equation

$$x+\log_{10} x=10.$$

Solution by Herbert I. Spiro, Storrs, Conn.

Using Newton's method of approximating the roots of an equation, a root is found between 9 and 10. Using Taylor's expansion about 9, we get,

(1) $f(9)+f'(9)(x-9)=0$, where $f(x)=x+\log_{10} x-10$ and $f'(x)=1+\dfrac{\log_{10} e}{x}$.

We find

$$f(9)=9+.95424-10=-.04576.$$

Also

$$f'(9)=1+\frac{.43429}{9}=1.04825.$$

Hence from (1)

(2) $-.04576+1.04825(x-9)=0$, from which $x=9.04366$.

Solutions were also offered by Charles W. Trigg, Cumnock College, Los Angeles, John N. Meighan, Clyde, Ohio, B. Felix John, W. E. Buker, Leetsdale, Pa., Richard A. Miller, University of Miss., and Maxwell Reade, Brooklyn, N. Y.

1392. *Proposed by Adrian Strunk, Paterson, N. J.*

AD is the altitude upon the hypotenuse BC of the right triangle ABC. X, Y, Z, are non-collinear points whose distances from a fixed point 0 are such that $OX=AB$, $OY=AC$, $OZ=AD$. OX, OY, OZ (or XO, YO, ZO) produced meet the circle XYZ in X', Y', Z', respectively. Prove that a right triangle exists with the hypotenuse equal to OZ', and legs equal to OX' and OY'.

Solution by the Proposer

Let $AB=OX=c$, $AC=OY=b$, $AD=OZ=p$, $BC=a$, $O'X'=c'$, $OY'=b'$, $OZ'=p'$.

Since ΔABC is a rt. Δ and $AD\perp BC$, $\Delta ABD\sim\Delta ABC$.

Hence

$$\frac{c}{p}=\frac{a}{b},\quad \text{or}\quad \frac{c^2}{p^2}=\frac{a^2}{b^2}.$$

Dividing by c^2,

$$\frac{1}{p^2}=\frac{a^2}{b^2c^2}.$$

Since ΔABC is a rt. Δ,

$$a^2=c^2+b^2.$$

Hence

$$\frac{1}{p^2}=\frac{c^2+b^2}{b^2c^2}.$$

That is,

$$\frac{1}{p^2}=\frac{1}{b^2}+\frac{1}{c^2}.$$

Since the chords XX', YY', ZZ' are concurrent,

$$pp'=bb'=cc'.$$

Let

$$k=pp'=bb'=cc'.$$

Then

$$p'=\frac{k}{p}, \quad b'=\frac{k}{b}, \quad c'=\frac{k}{c}.$$

Multiplying the equation

$$\frac{1}{p^2}=\frac{1}{b^2}+\frac{1}{c^2} \text{ by } k^2 \text{ we obtain}$$

$$\left(\frac{k}{p}\right)^2=\left(\frac{k}{b}\right)^2+\left(\frac{k}{c}\right)^2.$$

Hence

$$p'^2=b'^2+c'^2.$$

Therefore there exists a right triangle with hypotenuse equal to OZ', and legs equal to OX' and OY'.

Solutions were also offered by Charles W. Trigg, Los Angeles, W. E. Buker, Leetsdale, Pa., Isadore Chertoff, Bayonne, N. Y., Maxwell Reade, Brooklyn, N. Y., and B. Felix John.

1393. *Proposed by Aaron Buchman, Buffalo, N. Y.*

Prove: If the focus of any parabola coincides with the center of any circle, and the vertex of the parabola lies within the circle, then the tangent to the parabola at its vertex bisects every chord of the circle which, if extended, is tangent to the parabola.

Solution by W. E. Buker, Leetsdale High School, Leetsdale, Pa.

Let the equation of the parabola be $y^2=2px$. The vertex of this parabola is at the origin and the focus is at $(\frac{1}{2}p, 0)$ Then the equation of the circle is $(x-\frac{1}{2}p)^2+(y)^2=r^2$. (1) The tangent to theparabola at its vertex is $x=0$; and the tangent to the parabola at the point (x_1, y_1) is $y_1y=p(x+x_1)$ (2) To get the points at which the tangent (2) intersects the circle (1) we must solve the two equations of the curves simultaneously. Solving (2) for y and substituting in (1), we get

$$(x-\tfrac{1}{2}p)^2+\frac{p^2}{y_1^2}(x+x_1)^2=r^2, \text{ or}$$

$$\left(1+\frac{p^2}{y_1^2}\right)x^2+\left(\frac{2p^2}{y_1^2}x_1-p\right)x+\left(\frac{p^2}{y_1^2}x_1^2-r^2\right)=0. \tag{3}$$

Since the point (x', y') is on the parabola, we have $y_1^2=2px_1$. So the coefficient of x in (3) vanishes. This indicates that the two values of x which satisfy (3) are identical except for sign. So the line $x=0$ evidently bisects the chord joining the two points.

Solutions were also offered by H. Leo Juditz, New York City, Charles W. Trigg, Los Angeles, and the proposer.

HIGH SCHOOL HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems

submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1359. *H. C. Winter, Creighton Univ. H. S. (Nebr.).*

1378. *John Sheehan and Joseph Burke, Creighton, Nebr. University H. S.*

PROBLEMS FOR SOLUTION

1406. *Proposed by Maxwell Reade, Brooklyn.*

One may arrange 5 twos to get seven in this manner: $2.2.2.2-\frac{2}{2}=7$.

or $2+2+2+\frac{2}{2}=7$. Now

(1) Arrange five fours in such a way that 55 results.
(2) Arrange eight eights in order to get 1000.

1407. *Proposed by Walter H. Carnahan, Indianapolis.*

A circle is inscribed in triangle ABC and touches BC at P. Prove that the line drawn from the midpoint of AP to the midpoint of BC passes through the center of the circle.

1408. *Proposed by H. D. Grossman, New York.*

Through a given point between the sides of a given angle draw a line cutting off a triangle of given area.

1409. *Proposed by College Teacher.*

Evaluate

$$\sum_{1}^{n} \frac{x^2 \cdot 4^x}{(x+1)(x+2)}.$$

1410. *Proposed by Richard A. Miller, Univ. of Miss.*

Prove:

$$\log_e (1+3k)^{(1+3x)/6} \cdot (1-3x)^{(1-3x)/6} = \frac{3}{2}x^2+\frac{9}{4}x^4+\frac{81}{10}x^6+\cdots.$$

1411. *Proposed by William F. H. Godson, Jr., Norwood, Pa.*

Construct the two tangents from a point to a circle without drawing any arcs, i.e., by means of straight edges only.

SCIENCE QUESTIONS

October, 1935

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio

Readers are invited to co-operate by proposing questions for discussion or problems for solution.

Examination papers, tests, and interesting scientific happenings are very much desired. Please enclose material in an envelope and mail to Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

GUILD QUESTION RAISERS AND ANSWERERS (GQRA)

Join by sending in a question or an answer. Pupils and classes are eligible. Let your class propose a question or send an answer. Send in your question NOW.

JOIN THE GQRA

GQRA—NEW MEMBERS—OCTOBER

93. M. M. O'Reilley, Acting Director of the Mint.
94. Hugh L. Demmer, Custer City Schools, Custer, S. Dak.
95. G. H. Fett, University of Chicago.
96. Delfin Gatchalian, } Rizal High School,
97. Andrea Santiago, } Pasig,
98. Feliciano Dizon, } Rizal, P. I.
99. O. E. Underhill, Teachers College of Conn., New Britain, Conn.
100. Mary Beck, Lincoln High School, Cleveland, Ohio.
101. Norman Anning, University of Mich., Ann Arbor, Mich.

PHYSICS IN ADVERTISING

719. What could lift a 10-ton Stegosaurus one mile?

ANOTHER "THINK" PROBLEM

720. A princess had twelve suitors among whom she refused to choose. They finally agreed to ride their horses to a wood 5 miles away and that she should wed the *last* one to return to her castle.

They did as agreed but none would set out from the wood to ride back. An old witch lived in the wood and they consulted her on how to break the deadlock. She solved the problem by speaking two words. They all set off for the castle and the last to arrive won the princess. What *two* words did the witch speak?

SOMETHING WRONG?

672. A boat weighing 625 pounds displaces how much water?

Answer given 100.16 cu. ft. of water.

Is this correct? What's wrong? Mathematics or proof reading?

SOME QUESTIONS FOR GENERAL SCIENCE

721. *Proposed by Ralph J. Eschborn (elected to GQRA, No. 83) Riverside High School, Buffalo, N. Y.*

I am interested in becoming a member of the GQRA and am accordingly submitting a set of five questions for your consideration. I attend Riverside High School and Mr. Masson is my teacher.

1. When you walk in a moving train do you move faster than the train?
2. What causes the lateral motion (side to side) of a flag in the breeze?
3. Why does the pitch of the whistle keep changing as a train approaches, and recedes from the observer?

4. Why does iron feel colder to one's hand than wood even though both are at the same temperature?
5. Why does alcohol feel colder than the bottle from which it is poured?

PHYSICS TESTS

Try Them on Your Classes

722. *Submitted by Paul E. Wilson (GQRA, No. 41), Missoula County High School, Missoula, Mont.*

The following tests were used at the end of the first semester (January, 1934). I revised the test just before that time so previous scores would not be comparable.

The basis of marking is placed at the close of directions at head of each test. Some parts are marked on the basis of 2 points per question and other parts 1 point per question. The total possible score is 100. The time allowed on the entire test (Parts I–VI) was 50 minutes. Many pupils found the time limit rather short.

(PART I—was published as Question 678, November, 1934, SCHOOL SCIENCE AND MATHEMATICS.)

PART II—Each item correctly answered is scored 1 point. Maximum score on this part—10 points.

DIRECTIONS: The first column contains 10 terms. The second column contains expressions which are related to the first column. Find the term in the second column which is related to the term in the first column and write the number of it opposite the number of the question in the first column.

____ 1 Mechanical equivalent of heat.	1—Force X Distance
____ 2 Density	2—$\dfrac{\text{Weight of object}}{\text{Weight of equal volume of water}}$
____ 3 Distance traversed by a falling body.	3—Weight X height
____ 4 Dynes	4—$\dfrac{Wv^2}{2g}$
____ 5 Horsepower	5—$\dfrac{\text{Resistance}}{\text{Effort}}$
____ 6 Kinetic energy	6—Grams $\times$ acceleration
____ 7 Mechanical advantage	7—$\dfrac{\text{Foot pounds per minute}}{33{,}000}$
____ 8 Potential energy	8—778 foot pounds
____ 9 Specific gravity	9—$\dfrac{\text{Weight}}{\text{Volume}}$
	10—$\frac{1}{2}gt^2$
____ 10 Work	11—$2as$
	12—$\dfrac{\text{Force of friction}}{\text{Total normal pressure}}$

SPECIFIC GRAVITY

723. *Proposed by O. E. Underhill, Bureau of Teacher Preparation, Teachers College of Connecticut, New Britain, Conn. (Elected to GQRA, No. 99.)*

Here is my application to join the GQRA.

In regard to the diagram p. 376 in SCHOOL SCIENCE AND MATHEMATICS for April 1935 showing three sinkers suspended in salt water, alcohol and water respectively.

a. what is the weight of the sinker and of what material might it be made;

b. what is the density of the salt solution;

c. what is the density of the alcohol

in order to make possible the scale readings as indicated in the diagram?

WHY THE LATH MARKS

711. *Proposed by R. T. Harling, Memorial University College, St. Johns, Newfoundland. (Elected to GQRA, No. 68.)*

I should like to propose the following for your "Science Questions." I have sought in vain for an answer in the textbooks.

"When dust settles on the plastered walls and ceiling of a room, it does not do so evenly. After it has accumulated sufficiently, the rafters and laths behind the plaster may be seen clearly worked out in a lighter tone than the remainder. How does the woodwork behind an inch thickness of plaster affect the settling of dust on the surface? Further, if there is a crack in the plaster of a vertical wall, the plaster on the lower side of the crack remains much cleaner than that on the upper side; and all edges where two walls meet also remain markedly free from deposit. What is the reason for these facts?"

Answer by Miss Mary Beck (Elected to GQRA, No. 100), Lincoln High School, Cleveland, Ohio

Dust does not settle evenly on plastered walls because plaster is porous and acts as a filter and the laths offer more resistance to the circulation of air, which carries dust.

In my own home we had a great deal of trouble with the ceiling of a room which was below an unfinished storage space. We found that reducing the circulation of air by papering between the joists on the floor above and then flooring the storage space have solved our problem.

More dust settles above a crack than below because warm air goes up and dust with it. Above the crack the air would go through the plaster leaving dust on the surface. Air with dust would go through the crack leaving the edges clean. Dusty warm air below the crack would rise to the crack.

---

711. *Another answer submitted by Gilbert H. Fett (Elected to GQRA, No. 95), University of Chicago, Chicago, Ill.*

Probably the best answer to this question is contained in an article by W. J. Hooper in *Physics*, 1, 61, 1931, on "The Deposition of Dust on Walls." Professor Hooper attributes the difference in amount of dust deposits to a difference in temperature in adjacent parts of the walls. The

part of the plaster at the lowest temperature as compared with surrounding areas will collect the greatest amount of dust.

Prof. Hooper checked this last statement experimentally by measuring the temperatures of two sections of the plaster, noting that the cooler area always appeared to have collected more dust. He built an experimental wall section and tested the dust deposition with cold air and warm air blowing through the section. When cold air was used, the plaster between laths was at a lower temperature than that directly under the laths, and dust deposited between laths. When warm air was the medium, dust was found directly below the laths. When the entire system of lath and plaster were at the same temperature, no lath marks were found.

In an ordinary wall section the frequent motion of the air keeps the plaster at a lower temperature compared with that directly below the lath. If the wall section were completely insulated, no marks should be observable. Where a horizontal crack occurs, using the same line of reasoning, the upper side of the crack, at a higher temperature, will collect the dust, the lower edge will remain comparatively clean. That the edges where two walls meet are free from dust may be attributed to the 2×4 uprights at the corner which act the same way as do the laths. A similar lack of deposition is often seen along joists.

Another explanation is given in Bureau of Standards Circ. No. 151, 1924. The reason given here is the difference in water absorption ability of plaster surfaces and plaster backed with lath. At points where the plaster is backed with lath, less moisture will accumulate, and hence the surface will be clean, while where the plaster is saturated dust will collect.

The explanation given by Prof. Hooper appears to be more nearly the correct one, but it does not give a picture of the mechanism which causes the dust to deposit on cool areas, rather than on warm ones.

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711. *Still another answer: By Charles C. D'Amico (GQRA, No. 49), Albion, New York.*

The reason for the facts stated by Mr. Harling is a matter, I believe, of vibrations set up in the room. Forced vibrations are set up in the walls and ceiling of the room. The woodwork behind the plaster, such as laths and rafters, transmits the vibrations due to any disturbances, such as walking in the room, sounds, and tremors in the ground adjoining the building, more easily than does the plaster. Thus the laths and rafters are centers of greater vibration and act as sort of antinodes. The rest of the plaster forms nodes. Also between the laths and rafters, the plaster is thicker and there is less chance of there being any loose plaster, so to speak. The greater vibrations of the laths and rafters prevent accumulation of dust and leaves the plaster over the woodwork in a lighter tone than the remainder. If there is a crack in the plaster of a vertical wall, the plaster on the lower side being continuous with the floor will respond more freely to vibrations and therefore remain freer from dust than the plaster above the crack. The edges of the walls also vibrate more freely than the rest of the walls, and very little dust will accumulate along the edges.

THE SAILBOAT PROBLEM

712. *Proposed by Bernard R. Ptaszkiewicz. (GQRA, No. 69) Riverside High School, Buffalo, N. Y.*

Problem: Provided there is no wind or water current acting upon a stationary sailboat, would motion be produced by a fan placed in two

positions stated below? And if so, would the motion be straight or circular?

First Condition: The electric fan placed so that it will produce air currents directly into the sail.

Second Condition: The electric fan placed so that it will produce air currents hitting one side of the sail and then sliding off at an angle.

Solution by David Woods (GQRA, No. 63), Albion High School, Albion, New York

In case one there would be no motion because the reaction caused by the fan against the air would counteract the reaction of the air currents set up by the fan, as in the case of an airplane propeller.

In case two there would be a counterclockwise motion caused by the reaction of the air against the sail forcing the nose around in a circular path. The fan would be the pivoting point of the boat. If the fan moved in any case Newton's Third Law of Motion would be false because there would be no equal and opposite reaction and energy would be being created. In the second case, however the Third Law applies. The fan is not being moved except in a pivoting motion and therefore is not contradictory to Newton's Law.

BOOK REVIEWS

The Structure and Properties of Matter, by Herman T. Briscoe, Professor of Chemistry, Indiana University. First Edition. pp. vii+420. 3.3×14.5×21 cm. 139 figures. Cloth. 1935. $3.75. McGraw-Hill Book Co., Inc.

This new book is designed for use as a textbook in those relatively new courses in colleges and universities which attempt to give to the student an elementary knowledge of the facts and theories relating to the nature and structure of matter. It is also designed to be useful to any interested student or graduate chemist who has the necessary background to read it intelligently.

The material which enters into the text has been gathered from the literature and made available to the student, who would otherwise have had a difficult task of seeking and sorting the great mass of literature on this subject which has been printed in the past twenty years or so. Professor Briscoe has, moreover, organized the material with all the skill of a splendid teacher and has related the newer theories to the older ones. The subject matter has also been tried out on several classes of students for several years so that it has been tested as to its acceptability.

That the character of the content may be made clear we add the following list of chapter headings. I—The Early History of the Atomic Concept. II—The Atomic-Molecular Hypothesis of the 19th century. III—The Periodic Classification of the Elements. IV—Radioactivity and the Radioactive Elements. V—The Electron. VI—Protons and other Positive Particles. VII—The Atomic Nucleus and the Determination of the Nuclear Charge. VIII—The Structure of Crystals. IX—The Structure of the Atom; The Octet Theory. X—Radiation. XI—The Structure of the Atom: The Bohr Theory and the Origin of Spectral Lines. XII—The Distribution of Electrons about the Nucleus. XIII—Valence. XIV—The New Quantum Mechanics.

A brief reading of portions of the book shows that Professor Briscoe has dealt with his subject with the utmost honesty of approach, confessing the limitations of our knowledge and keeping facts, and attempts to explain,

clearly in their separate classifications. Aside from the subject matter and its worth the text is a valuable exponent of the scientific method of approach. If no place is found for the book in formal courses every college and high school should have it in the Chemistry Departmental Library.

F. B. WADE

Science by Observation and Experiment, by Hanor A. Webb, Ph.D., Professor of the Teaching of Chemistry and General Science, George Peabody College for Teachers, and Robert O. Beauchamp, M.A., Instructor in Science the Demonstration School, George Peabody College for Teachers. $1.72. 14.5×20.5×2.8 cm. Cloth. 369 Figures. pp. xxii +697. 1935. D. Appleton-Century Co.

Whether or not one may believe in the advisability of exposing youthful pupils to as wide a range of subject matter as is provided in the nearly 700 pages of this text one has to admire the skill with which the material is organized for reception by the student. The unit plan, with topics within the unit, affords a natural treatment of the subjects. As the title implies, opportunity is provided for much experiment and observation, together with reference reading and the preparation of exhibits. The book covers all fields of science without leaning overmuch toward any particular field. The subject matter is well selected up to date and thoroughly scientific in character and many a teacher of a special science might find much that was news to him by a perusal of the text.

There is a great amount of valuable and practical information, not strictly of scientific character, given at intervals, such as the sections on clothing and on the raw materials of industry. Even the esthetic side of life is given considerable space, for example in connection with the home beautiful and the flower garden. An excellent "foreword to students" is furnished, and those pupils who are really *students* can profit largely by attention to it. Teachers of general science everywhere should see this new text. It should help them to put across a difficult task.

F. B. WADE

Fundamentals of Radio, by R. R. Ramsey, Professor of Physics, Indiana University. Second Edition. Cloth. Pages xiv+426. 15×23 cm. 1935. Ramsey Publishing Company, 615 East Third Street, Bloomington, Ind. Price $3.50.

For several years *Fundamentals of Radio* has been the leading textbook on the subject designed especially for use at the college level. It is sound in theory and modern in practice. The first three chapters outline the basic direct current phenomena and principles used in radio and the fourth chapter reviews the fundamentals of alternating current. These chapters are not designed to take the place of a foundation course in electricity but rather to point out the essentials needed in the study of radio. Considerable knowledge of electrical theory and practice is presupposed. But even with this plan of organization students not so well prepared but with enthusiasm for the subject and determination to master it will be able to use the book successfully because throughout the author has kept the mathematical theory to a minimum and emphasized practice. The diagrams and illustrations used are drawn from experimental and commercial circuits. The tables of data and the graphs used are compiled and drawn from actual observations thus giving reality to the theory.

The first edition of this book has been a decided success, and now after five years of continuous use in many parts of the country, Professor Ramsey has made a thorough revision, adding a considerable amount of new

material, bringing the developments of the past five years up to date, and correcting typographical errors which are always present in a first edition. Very important revisions have been made in several of the charts and fifty new illustrations added. Excellent sets of questions based on each chapter are included in the new volume thus providing ready-to-use assignments and giving valuable directed study. In its new form *Fundamentals of Radio* stands without a peer in this field.

G. W. W.

An Introduction to Astronomy, by Robert H. Baker, Professor of Astronomy in the University of Illinois. Cloth. 312 pages. 15×23 cm. 1935. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $3.00.

The great discoveries of recent years in astronomy, organization of amateur telescope makers clubs, the establishment of great planetariums in three of our large cities, and the organization of survey science courses in the rapidly developing junior colleges have all contributed to the demand for a new type of textbook in astronomy. Professor Baker's *Introduction to Astronomy* gives bright promise of fully meeting this demand. All who have enjoyed his interesting radio talks will recognize the easy conversational style also used in this book. This text presents astronomy as a subject to be enjoyed, a pleasant interesting recreation for starlit evenings, into which is woven much valuable information concerning time, the seasons, the calendar, location of places, etc. The author begins with the astronomical features near us; he points out the things that can be observed without the aid of complex and expensive instruments; describes

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the variations in the appearance of the skies at different times of the year; and closes with chapters on the Milky Way and beyond. Throughout the text, as they are needed, explanations are made of the great instruments and laws of astronomy: telescopes, the spectroscope, Kepler's laws of planetary motion, the sun's energy. This text is well written, accurate in all details, covers the essentials of the subject, and will certainly stimulate interest and further study by all who use it.

G. W. W.

Mathematics for Everyday Use, by John C. Stone and Virgil S. Mallory, State Teachers College, Montclair, New Jersey. Pages xi+532. 1935. Benj. H. Sanborn & Co., Chicago.

This book meets a need in the modern high school, where the rapid growth in high school registration has increased the need for a more practical type of examination based on the social demands of modern life, and embracing a social content adapted to the abilities of the slow-moving high school groups. The text is actually a prognostic course in mathematics and may serve to determine the future course of the pupil in mathematical studies.

In the selection of the material for this experimental textbook, the following objectives were kept in mind:

1. The material must be within the ability of the student.
2. Every topic selected must definitely and positively contribute to the social, home or community needs of the student.
3. Every topic must be of such a nature and presented in such a way as to interest the student and to convince him of its value to him.
4. The material must be presented in such a way as to develop desirable habits, attitudes, and appreciations.

Through actual use, with a background of experimentation and demonstrations, the authors have stressed the following features:

1. *Opportunity for activity* is provided through measuring, drawing, making models, ruling and making out budgets, constructing graphs, etc.
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3. *Ability to read and to follow directions* is considered so important that constant attention has been given to vocabulary limitations with a summary of all new mathematical terms given at the end of each unit.
4. *Graphic method of solving problems* to help the student see the freedom with which quantitative relationships may be represented in mathematics.
5. *Flexibility and a challenge to do one's best* are provided for through the grading of the exercises and by optional topics, with a minimum, medium and maximum course being offered.
6. *Appreciation of the need for accuracy* is developed throughout the text by emphasis upon checks and proof.
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MICHAEL J. EHRLICH

BOOKS RECEIVED

A First Course in Calculus, by Hermon L. Slobin, and Marvin R. Solt, The University of New Hampshire. Cloth. Pages xi+426. 13.5×20.5 cm. 1935. Farrar and Rinehart, Inc., 508 West 26th Street, New York, N. Y. Price $3.00.

New Methods in the Social Studies, by M. J. Stormzand, Professor of Education, Occidental College, and Robert H. Lewis, Department of Social Studies, San Fernando High School, Los Angeles, California. Cloth. Pages ix×223. 13.5×20.5 cm. 1935. Farrar and Rinehart, Inc., 508 West 26th Street, New York, N. Y. Price $1.75.

Elementary College Algebra, by Harry Waldo Kuhn, Professor of Mathematics, and James Henry Weaver, Professor of Mathematics, Both of Ohio State University. Cloth. Pages xvi+359. 12.5×19.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.00.

Fundamentals of College Mathematics, by Charles Harold Helliwell, Arthur Tilley, and Howard Elmer Wahlert of the Department of Mathematics, Washington Square College, New York University. Cloth. Pages xiii+406. 13×20 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.50.

Study Arithmetics, Grade III, by F. B. Knight, J. S. Studebaker, G. M. Ruch, and W. C. Findley. Cloth. 336 pages. 13×19 cm. 1934. Scott, Foresman and Company, 623 South Wabash Avenue, Chicago, Ill. Price 76 cents.

Plane Trigonometry, by H. L. Rietz, Professor of Mathematics, University of Iowa; J. F. Reilly, Professor of Mathematics, University of Iowa; and Roscoe Woods, Associate Professor of Mathematics, University of Iowa. Cloth. Pages x+142+72+x. 13.5×21.5 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $2.20.

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Science of Living Things, by B. A. Walpole, Associate Professor in Agricultural Education, Michigan State College. Paper. Pages vi+130. 21×28 cm. 1935. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 52 cents.

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A Textbook of Algebra, by William H. H. Cowles and James E. Thompson, Department of Mathematics, School of Science and Technology, Pratt Institute. Cloth. Pages xi+402. 15×23 cm. 1935. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.25.

The Rise of Modern Physics, by Henry Crew, Professor Emeritus of Physics in Northwestern University. Second Edition. Cloth. Pages xix +434. 12.5×18.5 cm. 1935. The Williams and Wilkins Company, Baltimore, Maryland. Price $4.00.

In Training for Health, by C. E. Turner, Professor of Biology and Public Health, Massachusetts Institute of Technology, Director of Health Education Studies at Malden, Massachusetts, Chairman of the Health Section, World Federation of Educations; and Jeanie M. Pinckney, Chief, Bureau of Nutrition and Health Education, University of Texas. Revised. Cloth. Pages vii+152. 12.5×18.5 cm. 1935. D. C. Heath and Company, Boston, Mass. Price 60 cents.

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Jones-Wheat Arithmetics, by Robert L. Jones, Superintendent, Memphis City Schools, Memphis, Tennessee, and Harry G. Wheat, Professor of Education, West Virginia University, Morgantown, West Virginia. Cloth. 2×19 cm. 1935. Book I, pages v+341, price 64 cents. Book II, pages vii+365, price 64 cents. Book III, pages vii+408, price 72 cents. D. C. Heath and Company, 285 Columbus Avenue, Boston, Massachusetts.

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The Fundamentals of General Chemistry, by Perry A. Bond, Associate Professor of Chemistry, State University of Iowa. Cloth. Pages x+411. 13.5×20.5 cm. 1935. Farrar and Rinehart, Inc., 508 West 26th Street, New York, N. Y. Price $3.00.

French Pronunciation, by Jeanne S. Marie. Paper. Pages iii+70. 14×21.5 cm. 1935. The Peter Reilly Company, 133 N. 13th Street, Philadelphia, Pa. Price 60 cents.

The Nature Hour, by Lucille Nicol, Assistant Superintendent, Public Schools, New York City; Samuel M. Levenson, Principal, Public Schools, New York City; and Teressa Kahn, Teacher of Nature Study, Public Schools, New York City. Cloth. 13×19 cm. 1935. Fifth Year—Autumn and Winter, pages viii+118+ii. Spring, pages viii+114+iii. Price 76 cents each. Sixth Year—Autumn and Winter, pages viii+132+iii. Spring, pages viii+134+ii. Price 80 cents each. Silver, Burdett and Company, 39 Division Street, Newark, New Jersey.

Fundamentals of Radio, by R. R. Ramsey, Professor of Physics, Indiana University. Second Edition. Cloth. Pages xiv+426. 15×23 cm. 1935. Ramsey Publishing Company, 615 East Third Street, Bloomington, Ind. Price $3.50.

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Introductory College Mathematics, by William E. Milne, Professor of Mathematics, Oregon State College, and David R. Davis, Associate Professor of Mathematics, State Teachers College, Montclair, New Jersey. Cloth. Pages xiv+383+ii+64. 15×23 cm. 1935. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $3.00.

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Elementary Differential Equations, by Lyman M. Kells, Associate Professor of Mathematics at the U. S. Naval Academy, Second Edition. Cloth. Pages xii+248. 13.5×13.5 cm. 1935. McGraw-Hill Book Company, 330 West 42nd Street, New York, N. Y. Price $2.00.

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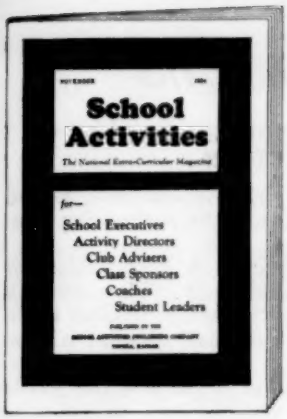

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